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National Aeronautics and
Space Administration

Langley Research Center
Hampton, Virginia 23665
AC 804 827-3966

CONTRACT NO. NAS 1-15642

MISSION SPECIFICATIONS

FOR

THREE GENERIC MISSION CLASSES

FINAL REPORT

14 APRIL 1979

Prepared For

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LANGLEY RESEARCH CENTER
HAMPTON, VIRGINIA

By

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PREFACE

This document is the final report of the Generic Mission Study (Mission Specifications for Three Generic Mission Classes) performed by the General Electric Company's Space Division for the Langley Research Center. The study was performed under contract NAS 1-15642.

The report presents a summary of all work completed by General Electric in chart form, with additional data and commentary presented where appropriate. The major output of the study, the generic mission specifications, is included as a detachable appendix at the end of the report.

The effort which culminated in this report was accomplished by several engineering staff members at General Electric. Key roles were played by Al Alvarado, who originated much of the mission and measurements requirements data, and by John Conrad, who surveyed and defined candidate sensor concepts. For further information on this study methodology and results, either of the following persons should be contacted:

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I. INTRODUCTION AND SUMMARY

Successful utilization of the nation's space capabilities in the 1990s and beyond will require that missions be designed to meet the needs of their intended beneficiaries. In the earth resources and environmental discipline area, this means that measurement systems sent aloft must satisfy the spatial, spectral, and temporal requirements of a wide range of users. Further, the sensing systems must satisfy these requirements in a cost-effective manner that takes maximum advantage of common equipment and economies of scale. This study provides a first step toward that end by defining generic mission concepts that satisfy a broad spectrum of earth resources and environmental mission objectives.

The intent of this study is to generate mission specifications for three generic mission classes to provide a baseline for definition and analysis of Data Acquisition Platform (DAP) system concepts. The mission specifications define compatible groupings of sensors that satisfy specific earth resources and environmental mission objectives. The driving force behind the definition of sensor groupings is mission need; platform and STS constraints are of secondary importance.

The three generic mission classes are: (1) low earth orbit sun-synchronous; (2) geosynchronous; and (3) non-sun-synchronous, non-geosynchronous. These missions are chosen to provide a variety of sensor complements and implementation concepts. Each mission specification relates mission categories, mission objectives, measured parameters, and candidate sensors to orbits and coverage, operations compatibility, and platform fleet size. The mission definitions developed in this study are undoubtedly subject to modification, revision, and updating, but at this point in time they establish a documented baseline for future mission and systems definition activities.

OBJECTIVE AND APPROACH

OBJECTIVE/DELIVERABLES - Three missions are defined and documented in a Final Report. An Implementation Plan was submitted in the first week of the study and is included as Appendix C. (p.3)

APPROACH - Six steps lead from mission objectives to mission definitions. (p

SCHEDULE - The six steps of the approach are six tasks scheduled for performance in December 1978 and January 1979. A preliminary Final Report is scheduled for February, with final submitted in mid-April. (p.5)

PLANNED ACTIVITY TO MIDTERM - the first month's activity includes preparation of the Implementation Plan and performance of study tasks 1, 2, 3, and part of 4. (p.6)

SECOND MONTH ACTIVITY - The second month is devoted to performance of the latter part of task 4 and tasks 5 and 6. (p.7)

OBJECTIVE/DELIVERABLES

OBJECTIVE: DEFINE EARTH RESOURCES AND ENVIRONMENTAL MISSIONS FOR DATA ACQUISITION PLATFORMS IN

- SUN SYNCHRONOUS ORBIT
- GEOSYNCHRONOUS ORBIT
- NON SUN SYNCHRONOUS/NON GEOSYNCHRONOUS ORBIT

IDENTIFY MISSION CATEGORIES, MISSION OBJECTIVES, MEASURED PARAMETERS, SENSOR DESCRIPTIONS, AND MISSION PARAMETERS

DELIVERABLES:

1) IMPLEMENTATION PLAN SUBMITTED 12/5/78
2) FINAL REPORT
   - MISSION SPECIFICATIONS AND SUMMARY MATERIAL FROM ORAL PRESENTATIONS
   - PRELIMINARY SUBMITTAL BY 1/31/79
   - FINAL BY 4/14/79

APPROACH

MISSION OBJECTIVES →	CANDIDATE SENSORS →	OPERATING REQUIREMENTS →	MISSION COMPATIBILITY →	SENSOR COMPLEMENTS →	MISSION DEFINITIONS
• EXISTING SOURCES - PLACE - GSS - EVAL - TERSSE - NIMBUS	• MEASUREMENT PHENOMENA	• ORBITS	• ALTITUDE	• VIEWING	• MISSION FEASIBILITY
• MISSION CATEGORIES	• SENSOR CONCEPTS	• TARGETS	• INCLINATION	• POINTING	• GENERIC MISSIONS - SUN SYNCH - GEO SYNCH - OTHER
• KNOWLEDGE REQUIREMENTS	• SENSOR CATEGORIES	• VIEWING	• ORIENTATION	• DUTY CYCLE	• MISSION SPECIFICATIONS
		• CONFIGURATION	• REPEAT CYCLES	• EMI	

SCHEDULE

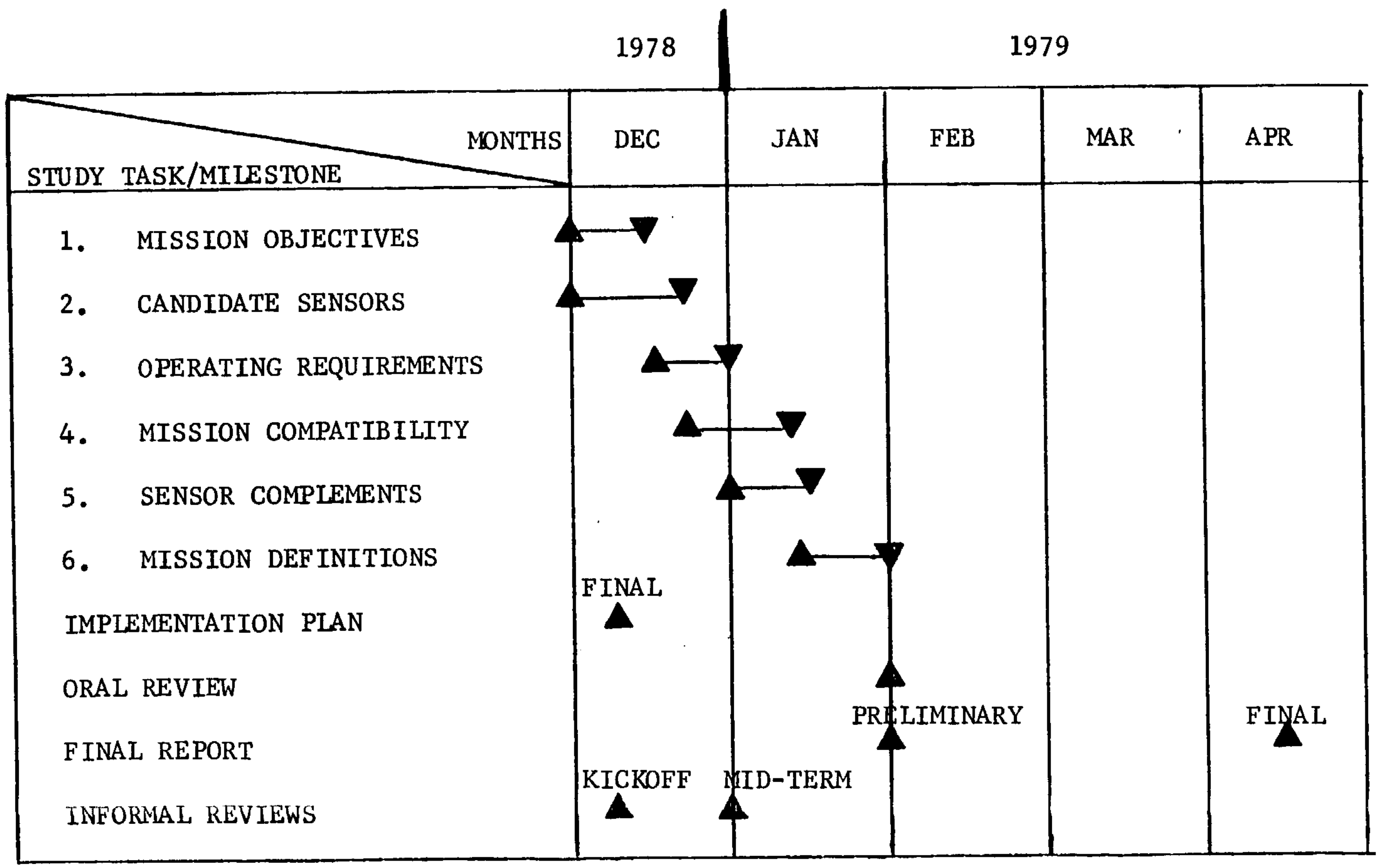

Figure 3-1. Task and Milestone Schedule

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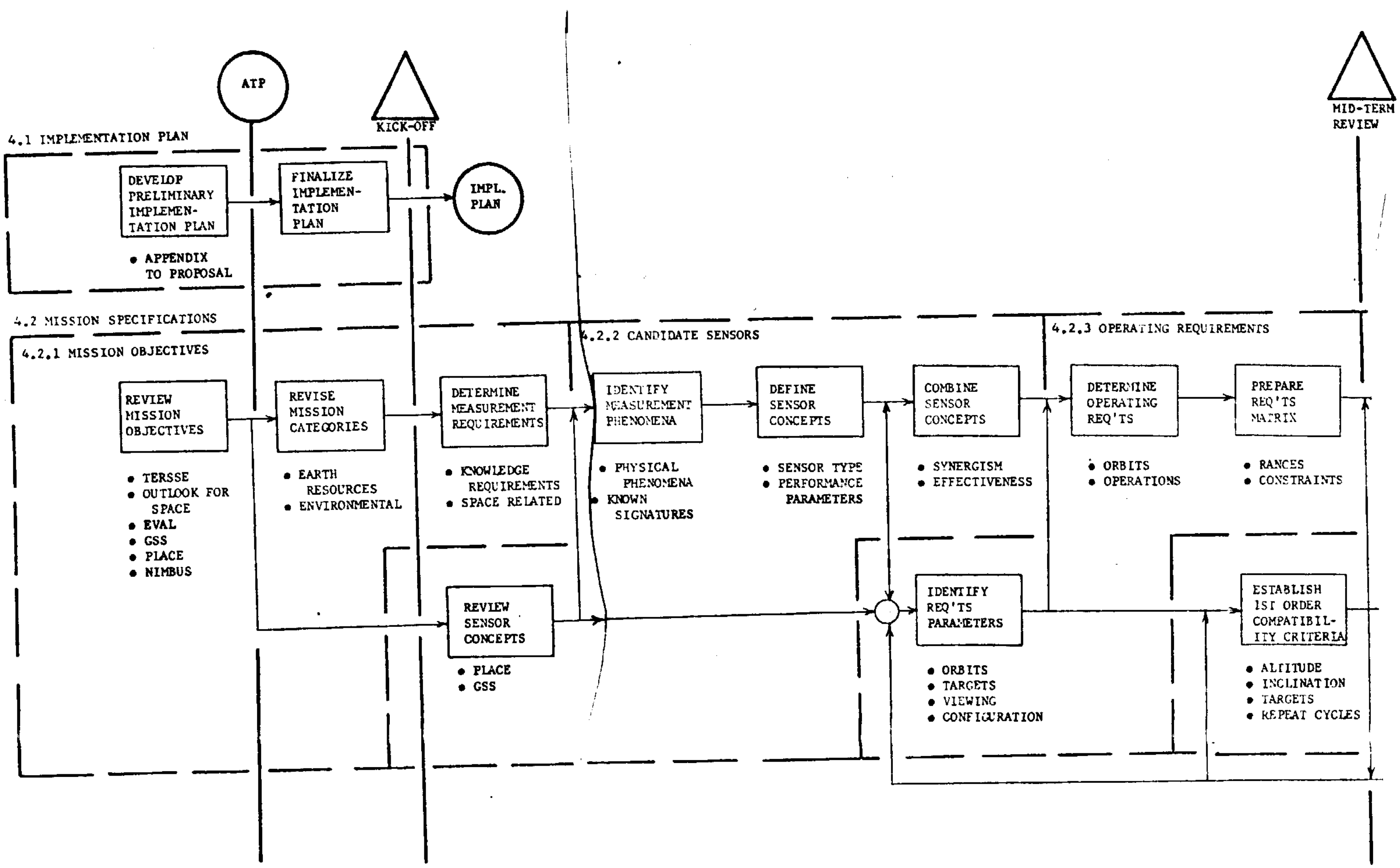
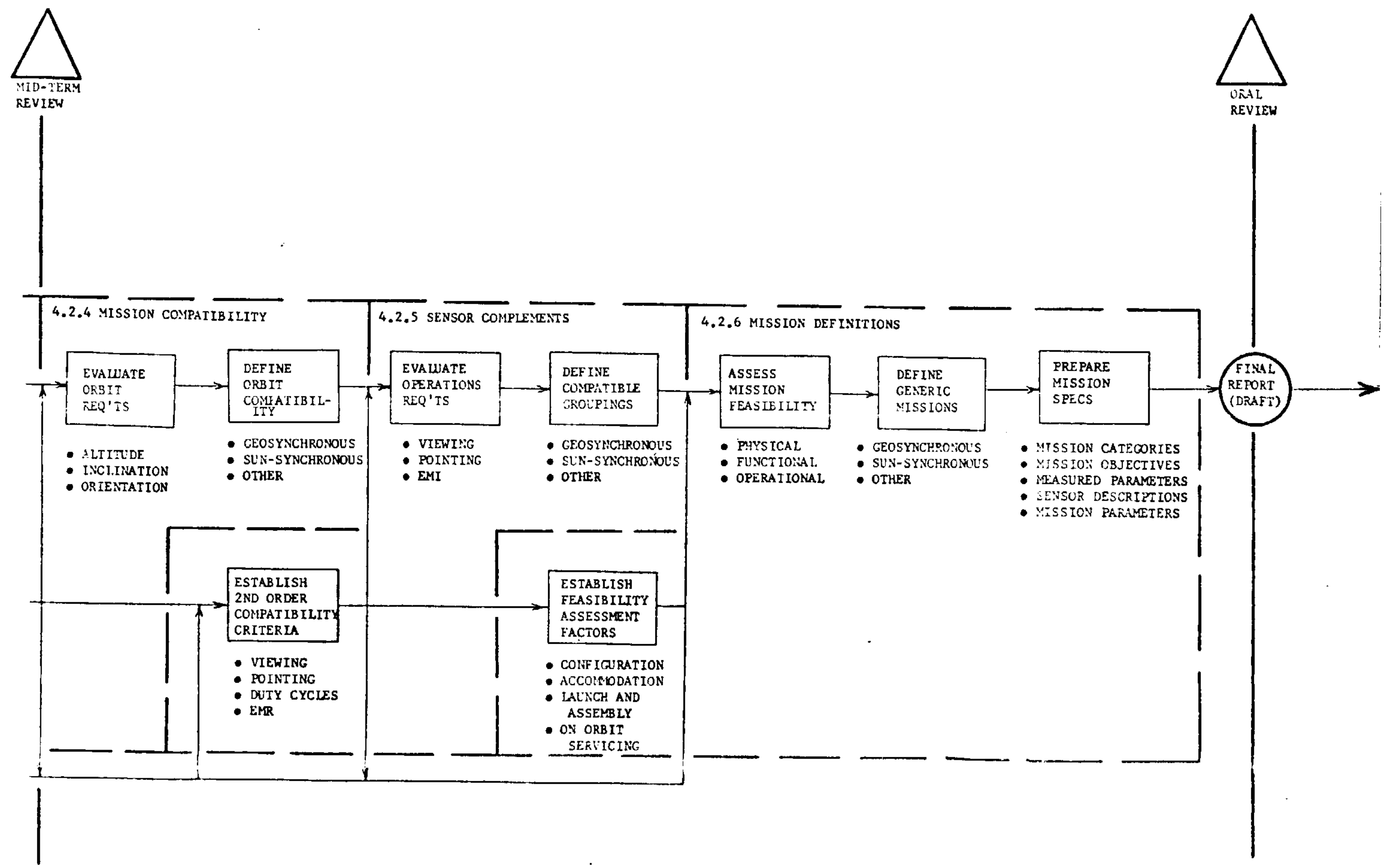
PLANNED ACTIVITY TO MIDTERM



SECOND MONTH ACTIVITIES



STUDY SUMMARY

SENSOR IDENTIFICATION - Earth resources and environmental mission categories each present numerous measurement requirements which may be unique to that category or common to two or mote caregories. The measurement requirements define measurements which may in turn be unique or common. A finite number of sensors satisfies requirements for the full set of mission categories. (p.9)

METHODOLOGY - Measurement requirements and sensor performance are matched across a spectrum of operating parameters to define candidate sensors. (p.10)

RELATIONSHIPS OF PARAMETERS - Various parameters impact different aspects of mission definition. Spectral parameters have little effect on orbit or operations. Spatial and temporal parameters primarily affect altitude. Targets and sensitivities affect orbit, while targets, pointing, and EMR affect operations. Sensor size, shape, and accommodation requirements affect mission feasibility, along with military/political restrictions and installation/maintenance requirements. (p.11)

KEY OPERATING PARAMETERS - Sensor/measurement type, spectral, spatial, and mission performance are the key operating parameters. (p.12)

OPERATIONAL COMPATIBILITY - Sensor to orbit compatibilities and sensor to sensor compatibilities are established. (p.13)

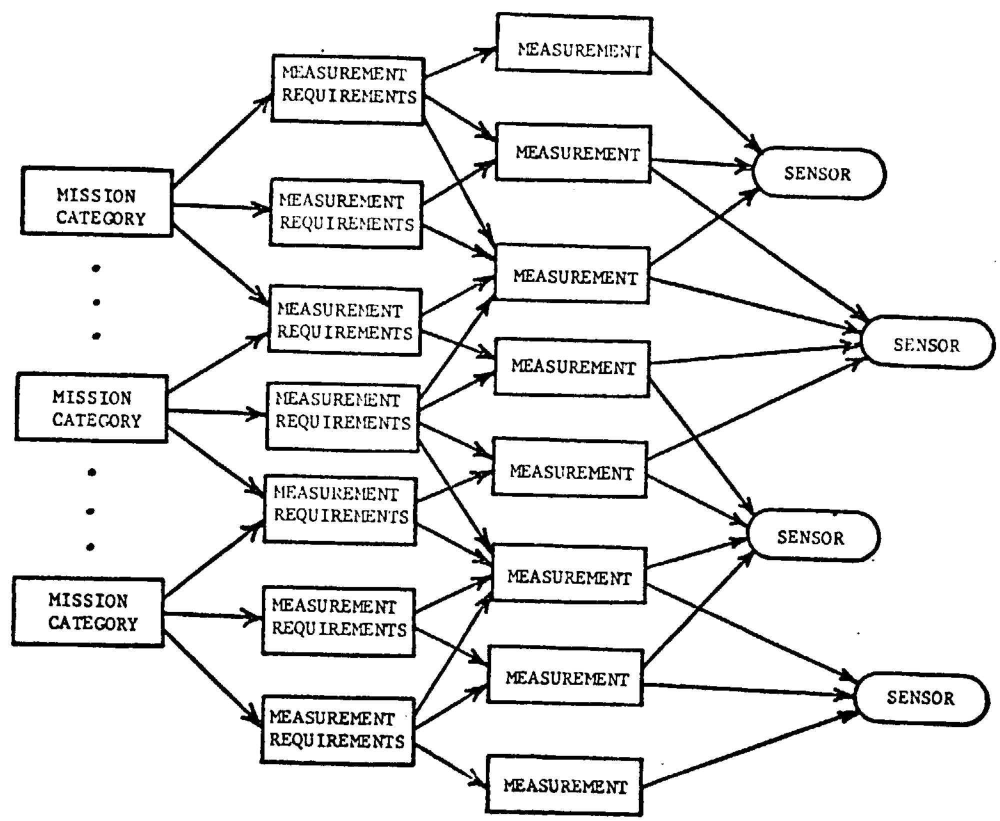
MISSION DESCRIPTIONS - Mission feasibility is assessed and mission specifications are prepared. (p.14)

GENERIC MISSIONS - Three generic missions are defined. Complete mission specifications appear in Appendix B. (p.15)

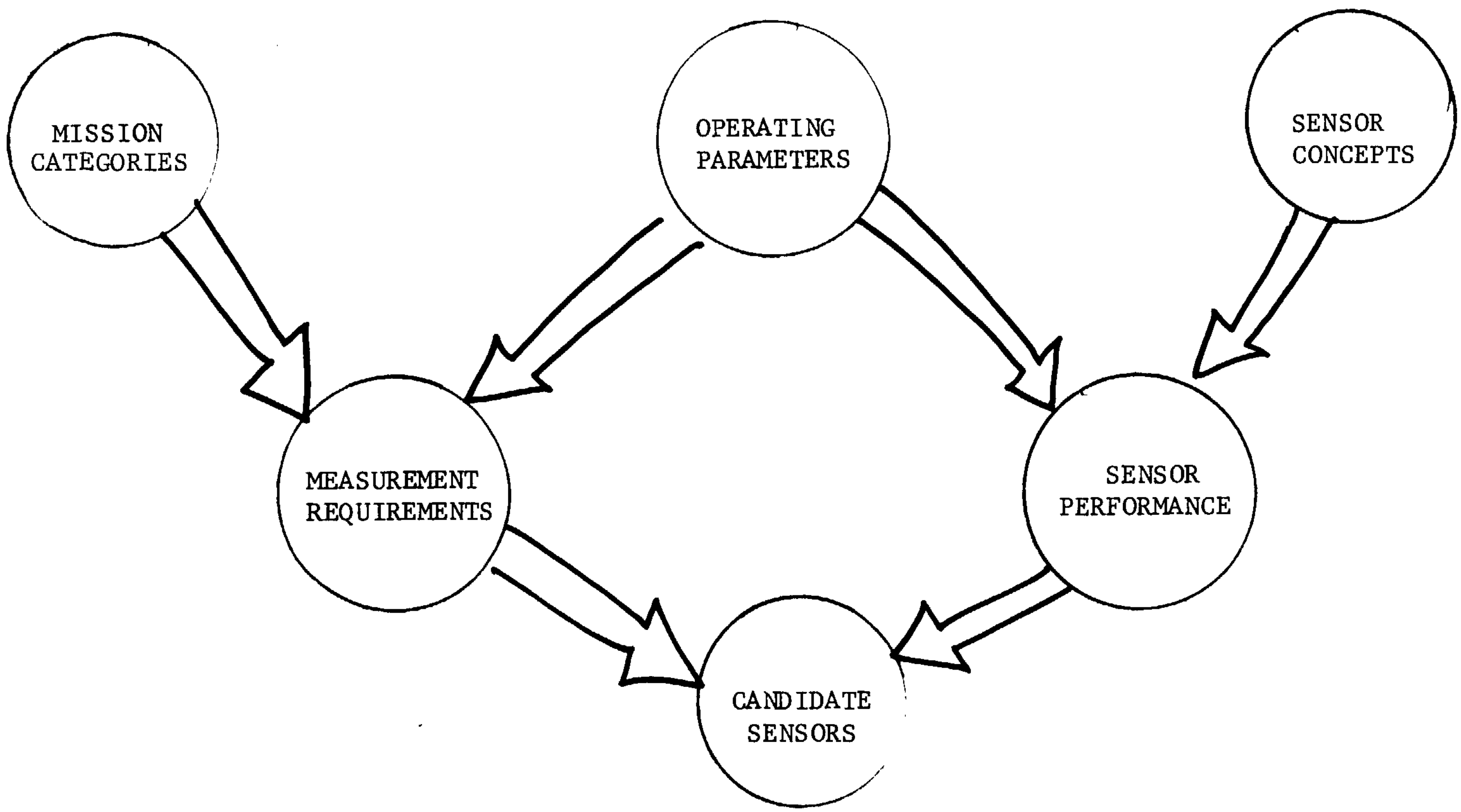
MISSION SUMMARIES - Sensors are assigned to missions through analysis of measurement requirements. Detailed traceability to mission categories is provided in the mission specifications, Appendix B. (p.16)

The generic missions developed in this study are a first step in defining potential DAP missions. Further iterations using the methodology developed during this study are recommended.

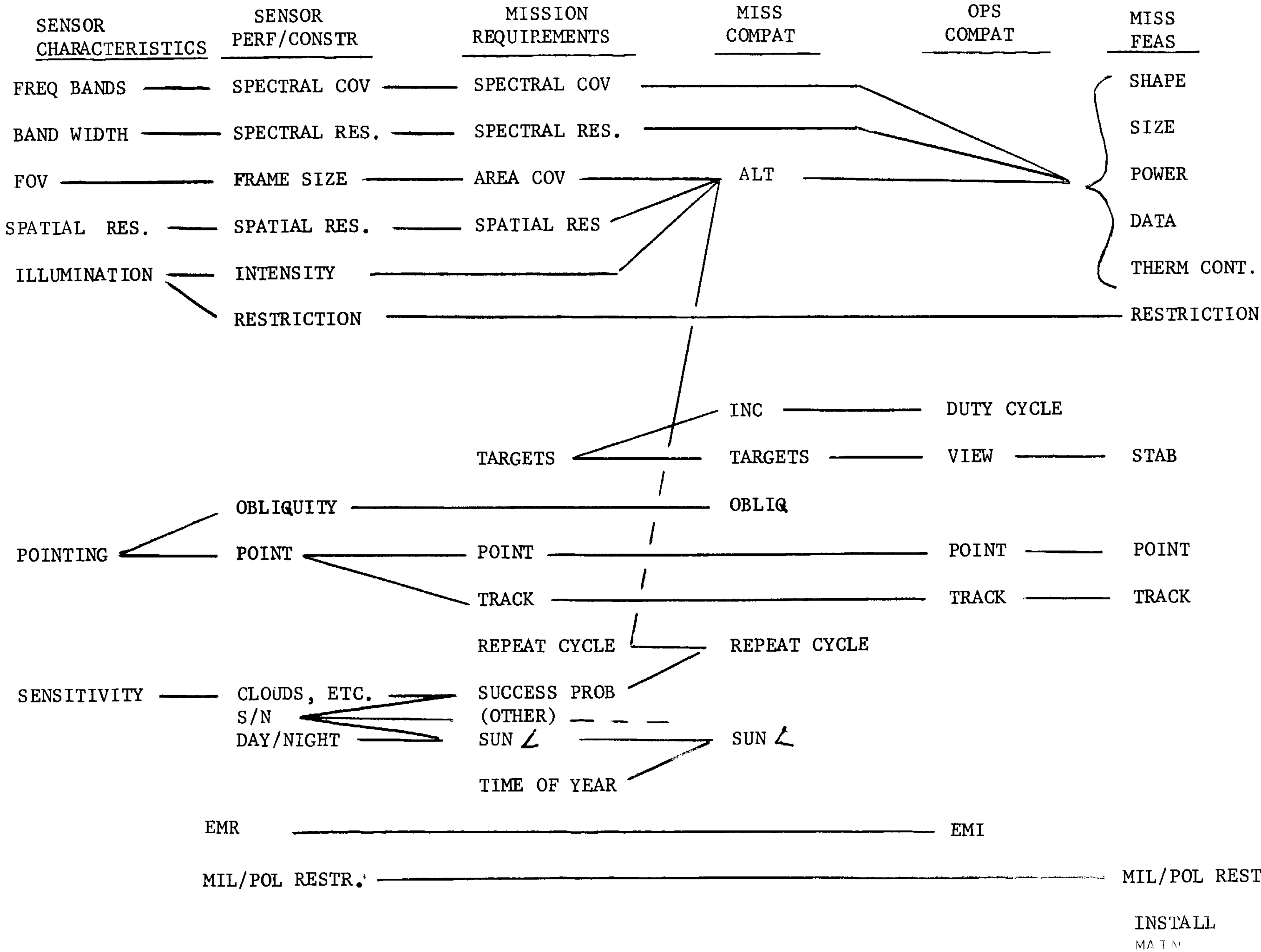
SENSOR IDENTIFICATION



METHODOLOGY



RELATIONSHIPS OF PARAMETERS



KEY OPERATING PARAMETERS

SENSOR/MEASUREMENT TYPE	• MAPPER; SOUNDER/ALTIMETER, DETECTOR/SCATTEROMETER • ACTIVE/PASSIVE
SPECTRAL PERFORMANCE	• FREQUENCY REGIME (γ/X-RAY, UV, VIS, IR, MW) • NUMBER OF CHANNELS (MANY, SOME, FEW) • BAND WIDTH (NARROW, WIDE)
SPATIAL PERFORMANCE	• POINTING (NADIR, OFF NADIR, LIMB, POINTABLE) • FIELD OF VIEW (WIDE, MEDIUM, NARROW) • SPATIAL RESOLUTION (COARSE, MEDIUM, FINE)
MISSION PERFORMANCE (TEMPORAL/COVERAGE)	• REPEAT CYCLE (SEVERAL PER DAY, DAILY, EVERY FEW DAYS, SEMI-MONTHLY, MONTHLY, QUARTERLY, ANNUALLY) • TARGETS (WHOLE EARTH, TEMPERATE ZONES) • COVERAGE (COMPLETE, PARTIAL, SPOT)

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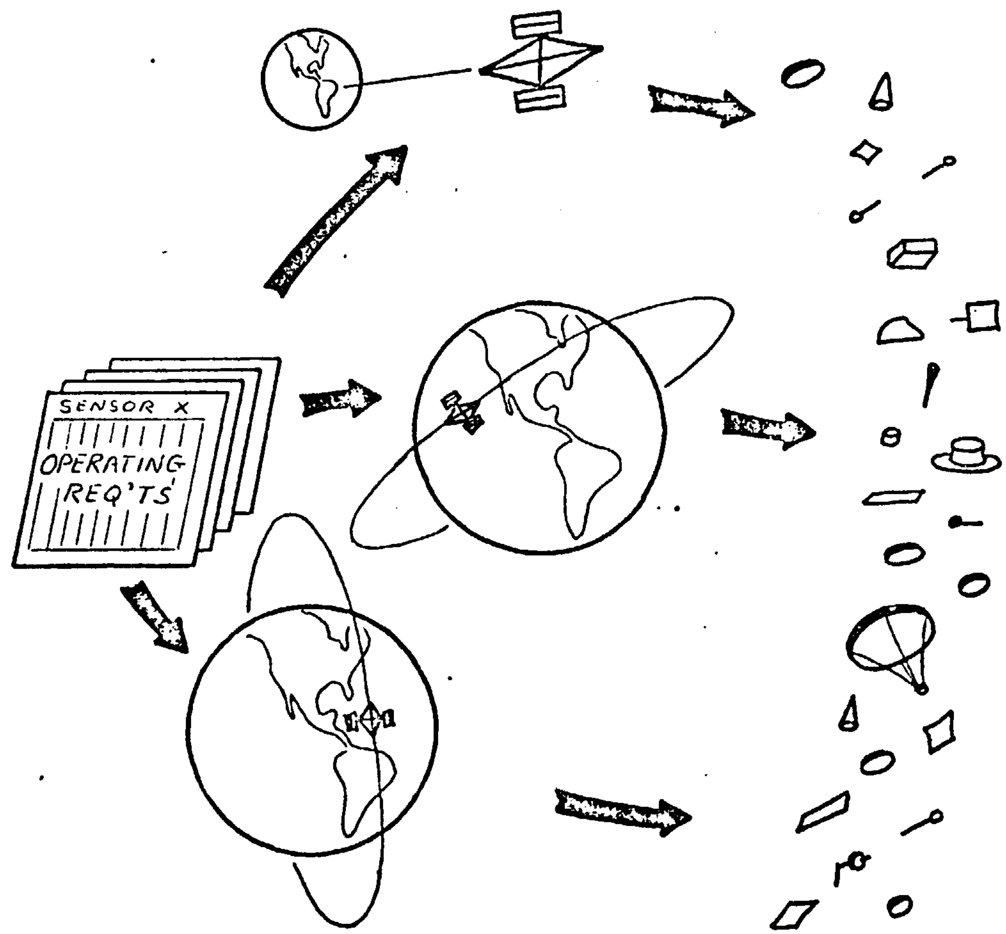
OPERATIONAL COMPATIBILITY



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MISSION DESCRIPTIONS

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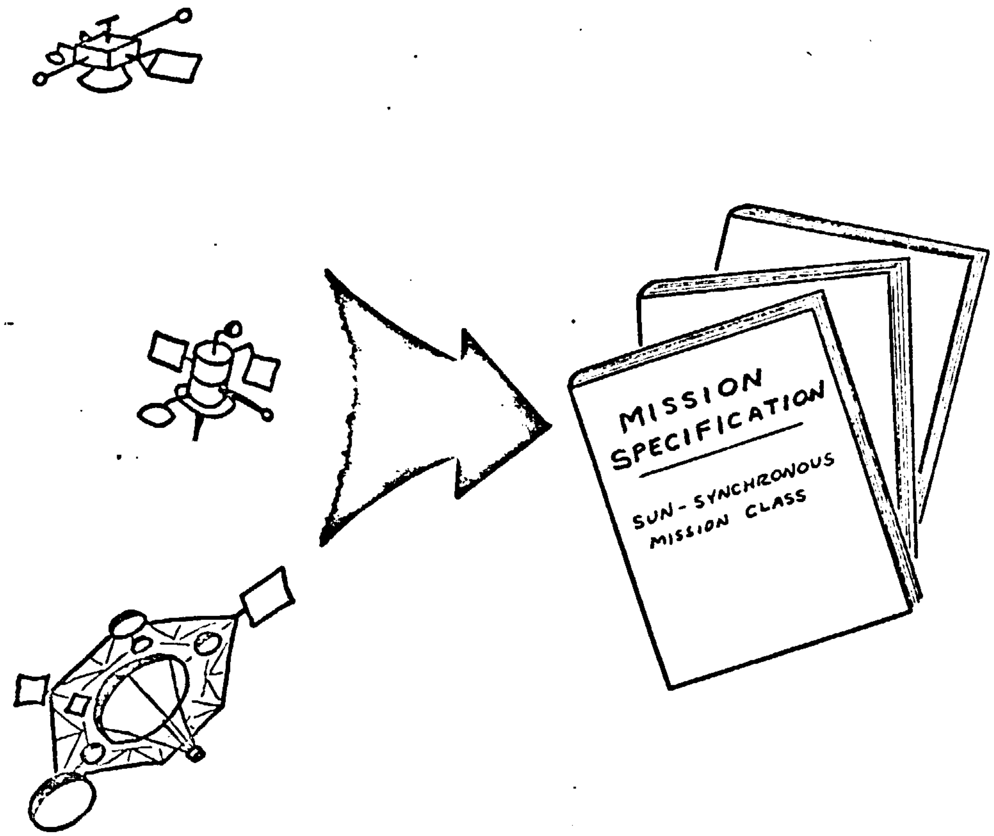

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GENERIC MISSIONS
(ORBITS & COVERAGE)

SUN SYNCHRONOUS

- 955 NMI (1770 KM) CIRCULAR ORBIT AT 103.6° INCLINATION
- 5 DAY REPEAT CYCLE IN 59 REVOLUTIONS
- 1 PRIMARY AND 4 SECONDARY PLATFORMS IN 9:00 AM ORBIT
- 1 SUPPLEMENTAL PLATFORM IN 3:00 PM ORBIT
- DAILY COVERAGE OF ABRUPT EVENTS AND TRANSIENT PHENOMENA

GEOSYNCHRONOUS

- NEAR GEOSTATIONARY ORBIT WITH $\epsilon = .009$, $\dot{\iota} = 1^\circ$; CIRCULAR GROUND TRACK
- 4 PLATFORMS POSITIONED TO COVER MAJOR LAND MASSES
- CONTINUOUS COVERAGE OF ABRUPT EVENTS AND SYNOPTIC SURVEILLANCE

NON-SUN-SYNCHRONOUS, NON-GEOSYNCHRONOUS

- 880 NMI (1630 KM) CIRCULAR ORBIT AT 60° INCLINATION
- 15 DAY REPEAT CYCLE IN 181 REVOLUTIONS
- 1 PLATFORM IN ORBIT SUBJECT TO $\sim 6^\circ$/DAY PRECESSION RATE
- ALL WEATHER COVERAGE OF NON-DYNAMIC PHENOMENA

MISSION SUMMARIES

SUN SYNCHRONOUS MISSION

- 19 ASSUMED SENSORS
  - OPTICAL AND MICROWAVE MAPPERS
  - OPTICAL AND MICROWAVE SOUNDERS
  - MISCELLANEOUS ALTIMETERS AND DETECTORS
- 11 ADDITIONAL SENSORS WITH UNDEFINED MISSION REQUIREMENTS
  - OPTICAL AND MICROWAVE
  - FIELD/PLASMA SENSORS
  - DCP INTERROGATOR

ALL MISSION CATEGORIES, ESPECIALLY-
- DISASTER ASSESSMENT
- EARTH & OCEAN DYNAMICS
- WATER RESOURCES

GEOSYNCHRONOUS MISSION

- 3 ASSUMED SENSORS
  - GEOS, MMW MAPPER, GEOSAR
- 3 ADDITIONAL SENSORS WITH UNDEFINED MISSION REQUIREMENTS
  - γ-RAY, X-RAY, EUV DETECTORS

MOST MISSION CATEGORIES, INCLUDING-
- AGRICULTURE
- RANGE MGT
- FORESTRY
- WATER RES.

NON-SUN SYNCHRONOUS, NON-GEOSYNCHRONOUS MISSION

- 9 ASSIGNED SENSORS
  - OPTICAL AND MICROWAVE MAPPERS
  - LASER ALTIMETER
- 11 ADDITIONAL SENSORS WITH UNDEFINED MISSION REQUIREMENTS
  - SAME AS SUN SYNCHRONOUS MISSION

- AGRICULTURE
- RANGE MGT
- FORESTRY
- LAND USE
- EARTH & OCEAN DYNAMICS

II. MISSION OBJECTIVES DEFINITION (TASK 1)

A mission objectives baseline for the earth resources and environmental area has been developed in a number of past studies, most recently the PLACE Study performed by GE for GSFC in 1978. In addition, the GSS Circa 1995 study performed by JPL has contributed to this effort. Mission objectives used in the current study have been extracted from existing sources to the maximum feasible extent.

The mission objectives are analyzed for knowledge objectives and measurement requirements, expressed in terms of the spatial, spectral, and temporal parameters of the key requirements set.

MISSION CATEGORIES AND OBJECTIVES

MISSION CATEGORIES - Earth resources and environmental missions fall into 11 categories. (p.19)

MISSION OBJECTIVES - Each mission category includes a variety of mission objectives. (p.20 to p.30)

EARTH RESOURCES AND ENVIRONMENTAL MISSION CATEGORIES

A. AGRICULTURE

B. RANGE MANAGEMENT

C. FORESTRY

D. GEOLOGICAL RESOURCES

E. LAND USE

F. WATER RESOURCES

G. ENVIRONMENTAL QUALITY

H. DISASTER ASSESSMENT

I. WEATHER AND CLIMATE

J. ATMOSPHERIC PROPERTIES

K. EARTH AND OCEAN DYNAMICS

MISSION OBJECTIVES IN AGRICULTURE
(REFERENCE 1)

- IDENTIFY CROPS (THIS INCLUDES FRUIT TREES AND COTTON) TO LEVEL OF SPECIES AND VARIETY
- MEASURE THEIR ACREAGE AND LOCATION
- ESTIMATE THEIR YIELD FROM: VIGOR AND STRESS FACTORS (SOIL MOISTURE, CHEMISTRY AND FERTILIZER, AND PHYSICAL STRUCTURE; PLANT DISEASE, INSECT INFESTATION, AND WEED ENCROACHMENT; SOIL TEMPERATURE; WATER AND AIR POLLUTION), PLANTING TIME, AND DAMAGE (FROST OR WIND)
- DETERMINE PRODUCTION AND FOOD RESERVES FROM STOCKPILES AND AREAS WHICH HAVE BEEN HARVESTED; FORECAST PRODUCTION FROM ACREAGE AND YIELD FOR EACH CROP
- OPTIMIZE CROPS: TYPE OF CROP FOR EACH AREA, PLANTING TIME, AND SOIL AMENDMENTS
- PREDICT ONSET OF INSECT AND DISEASE ATTACK
- DESIGN IRRIGATION PROJECTS, GIVEN WATER NEEDS & RESOURCES;DETERMINE NEED FOR & TIMING OF IRRIGATION
- MAP SOIL TYPES AND DISTRIBUTION AND DETERMINE THEIR PRODUCTIVITY CAPABILITY
- MEASURE SOIL MOISTURE AND SALINITY
- MEASURE SOIL RADIOACTIVITY AND PESTICIDE RESIDUE
- MAP SOIL EROSION. BY WIND AND WATER. AND DEPOSITION

MISSION OBJECTIVES IN RANGE MANAGEMENT
(REFERENCE 1)

- INVENTORY RANGELAND AND CLASSIFY VEGETATION
- DETERMINE POTENTIAL FOR GRAZING, IN ANIMAL UNIT MONTHS
- MONITOR STATUS OF FORAGE: PALATABILITY, RANGE READINESS, POPULATION PRESSURE, AND STRESS
- PREDICT CARRYING CAPACITY OF RANGE, AND INVENTORY LIVESTOCK
- ESTIMATE GRASSLANDS FIRE POTENTIAL

MISSION OBJECTIVES IN FORESTRY
(REFERENCE 1)

- CREATE TYPE STAND CLASSIFICATION BY SPECIES
- MEASURE STAND AREA AND DENSITY DISTRIBUTION OF SPECIES GROUP
- DETECT TIMBER STRESS: DROUGHT, INSECT, DISEASE
- ESTIMATE STAND VOLUME AND GRADE (FACTORS: DIAMETER, MATURITY, AGE, HEIGHT, DENSITY)
- PREDICT SEED-BEARING YEARS
- MONITOR AND MEASURE PRODUCTION
- INVENTORY THE UNDERSTORY
- ESTIMATE FOREST FIRE POTENTIAL

MISSION OBJECTIVES IN GEOLOGICAL RESOURCES
(REFERENCE 1)

- MAP GEOLOGY (MORPHOLOGY, LITHOLOGY, STRUCTURE) AND VERIFY OR REVISE EXISTING MAPS
- LOCATE GEOLOGICAL RESOURCES: UNDERWATER, BENEATH VEGETATION, OR DEEPLY BURIED
- CORRELATE RESOURCES WITH THEIR SURFACE EXPRESSIONS (ANOMALOUS COLORS, TEXTURES, PATTERNS, AND VEGETATION AND ITS STRESS)
- LOCATE METALLIC MINERAL DEPOSITS (SEE GEOSAT COMMITTEE REPORT)
- EXPLORE FOR NONMETALLIC MINERALS AND CONSTRUCTION MATERIALS (FOR EXAMPLE, EVAPORITES, PHOSPHATE, LIMESTONE, CLAY)
- LOCATE FOSSIL FUELS: COAL, PETROLEUM, AND GAS
- LOCATE RADIOACTIVE ORES: URANIUM AND THORIUM
- EXPLORE FOR GEOTHERMAL AND GEOPRESSURE RESOURCES
- DETECT RIVER MIGRATION AND DELINEATE FLOOD PLAINS
- DETERMINE SUSCEPTIBILITY FOR LANDSLIDES, SUBSIDENCE, AND MINE CAVE-IN

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MISSION OBJECTIVES IN LAND USE
(REFERENCE 1)

- PRODUCE LAND USE MAPS TO LEVEL III CLASSIFICATION
- GENERATE THEMATIC MAPS AND ORTHOPHOTO MAPS
- DETECT CHANGE IN LAND USE (AGRICULTURAL LAND CONVERSION, FOR EXAMPLE)
- DETERMINE LAND CAPABILITY (POTENTIAL FOR A GIVEN USE)
- PERFORM GLOBAL DEMOGRAPHIC CENSUS
- MAP SETTLEMENT PATTERNS AND TRANSPORTATION NETS
- DETERMINE OPTIMUM ROUTES FOR TRANSPORTATION, COMMUNICATION, AND PIPELINES, AND OPTIMUM SITES FOR BUILDING AND INDUSTRY
- EVALUATE CONSTRUCTION CHARACTERISTICS AT A LOCATION AS DETERMINED BY GEOLOGY, SOIL, AND TOPOGRAPHY
- MONITOR HOUSING AND INDUSTRIAL HEAT LOSS
- MONITOR RECREATIONAL, ARCHAEOLOGICAL, AND HISTORICAL AREAS

MISSION OBJECTIVES IN WATER RESOURCES
(REFERENCE 1)

- FORECAST REGIONAL WATER BALANCE
- DETERMINE WATER AVAILABILITY AND CONSUMPTION
- MONITOR SNOWSHEDS AND WATER CONTENT OF SNOW
- MONITOR WATERSHEDS: FORECAST REGIONAL RUNOFF AND DETECT INCIPIENT FLOODS
- IDENTIFY AREAS SUITABLE FOR AQUACULTURE, BOTH VEGETATION AND FISH
- INVENTORY WATER BODIES, INCLUDING RESERVOIRS
- SELECT RESERVOIR SITES AND DETECT RESERVOIR SEEPAGE
- LOCATE GROUNDWATER RESOURCES
- MONITOR GLACIERS AND LAKE AND RIVER ICE
- MONITOR SEA ICE: DRIFT VELOCITY, EXTENT, THICKNESS, LEADS, AGE, SALT CONTENT, TEMPERATURE
- DETECT HAZARDS TO NAVIGATION IN THE OCEAN & INLAND WATERWAYS: LOCATION OF SHOALS & THEIR DEPTH, ICEBERGS
- ROUTE AND MONITOR SHIPPING: WEATHER, WAVES, AND CURRENTS
- MONITOR FISHING FLEET AND ITS CATCH
- MONITOR MARINE AND FRESH WATER PLANTS & ANIMALS (PLANKTON, FISH, RED TIDE, MAMMALS)
- DETERMINE OCEAN WATER TEMPERATURE AND COMPOSITION (CHLOROPHYLL, GELBSTOFFE, SALINITY, DISSOLVED OXYGEN, NUTRIENTS)
- MEASURE COASTAL ZONE CONDITIONS (EROSION, DREDGING, DUNE MIGRATION)
- MONITOR ESTUARIES (SALT-FRESH WATER INTERFACE, POLLUTION, VEGETATION)

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MISSION OBJECTIVES IN ENVIRONMENTAL QUALITY (REFERENCE 1)

- EVALUATE QUALITY OF LIFE INDICATORS
- MONITOR CHANGES IN CITIES (URBAN BLIGHT AND POPULATION DENSITY)
- ANALYZE URBAN HEAT ISLANDS
- DETECT OIL SPILLS ON LAND
- MONITOR WASTE DISPOSAL ON LAND: SEWAGE SLUDGE AND LAND FILL
- MONITOR RADIOACTIVE WASTE STORAGE
- MONITOR WILDLIFE, ITS HABITAT AREAS AND MIGRATION
- DETECT POLLUTION OF FRESH WATER; MAP ITS DISPERSION AND LOCATE ITS SOURCE (CHEMICAL, OIL, AND THERMAL POLLUTION)
- MONITOR QUALITY OF FRESH WATER BODIES: SALT WATER INCURSION; EUTROPHICATION; WATER SUSPENDED SOLIDS, THEIR PARTICLE SIZE AND CONSTITUENTS

MISSION OBJECTIVES IN DISASTER ASSESSMENT (REFERENCE 1)

DETECT, MONITOR, ASSESS DAMAGE, AND PLAN RELIEF FROM NATURAL AND MAN-INDUCED DISASTERS

- FIRES
- LANDSLIDE
- SUBSIDENCE
- EARTHQUAKES AND TSUNAMIS
- VOLCANO ERUPTIONS
- EXPLOSIONS
- RADIOACTIVITY DISPERSAL
- VIOLENT STORMS (HURRICANE,TORNADO, WIND, SNOW, AND ICE)
- FLOODS
- FROST

MISSION OBJECTIVES IN WEATHER AND CLIMATE

- WEATHER ASSESSMENT, PREDICTION
  - SHORT TERM, LONG TERM
  - SMALL SCALE, MACROSCALE
- DETERMINATION OF CLIMATIC TRENDS, FORECASTS
- LOCATION OF HAZARDOUS ICE AND SNOW CONDITIONS, FORECASTS
- LOCATION OF HAZARDOUS FOG CONDITIONS, FORECASTS
- GLACEOLOGY AND ICE RESEARCH
- MONITORING OF ICEBERGS
- CLOUD CLIMATOLOGY (RECOMMENDED BY OUTLOOK FOR SPACE STUDY)
- ENERGY BUDGET EVALUATION
- DETERMINE RELATIONSHIP BETWEEN WEATHER AND SOLAR ACTIVITY

MISSION OBJECTIVES IN ATMOSPHERIC PROPERTIES

- DETERMINE EFFECT OF ATMOSPHERIC POLLUTANTS, e.g.,
  - EFFECT ON OZONE CONCENTRATION
  - EFFECT ON ATMOSPHERE'S RADIATIVE TRANSFER
- ATMOSPHERIC EFFECTS OF VOLCANO ACTIVITY
- ASSESSMENT OF STRATOSPHERIC AEROSOL CONCENTRATION
- EVALUATION OF TROPOSPHERIC COMPOSITION AND POLLUTION
- ASSESSMENT OF ATMOSPHERIC TRANSPORT

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MISSION OBJECTIVES IN EARTH AND OCEAN DYNAMICS

- DETERMINE EXTENT OF TECTONIC MOVEMENTS
- DETECT AND MONITOR EARTH FAULTS
- DETERMINE OCEAN (SEA STATE) CONDITIONS, FORECASTS
- ASSESS UPWELLING CONDITIONS
- EVALUATION OF OCEAN CURRENTS AND THEIR DISPERSION OF POLLUTANTS
- STUDY AIR-OCEAN INTERFACE AND ITS EFFECTS
- DETERMINE TIDAL ACTIVITY
- ASSESS COASTAL ESTUARY CIRCULATION AND POLLUTION
- DETERMINE EXTENT AND DISTRIBUTION OF SEDIMENT TRANSPORT
- SHORELINE MOVEMENTS

MEASUREMENT REQUIREMENTS

REQUIREMENTS DERIVATION - Following a top-down approach, the knowledge requirements associated with each mission objective are determined. Measurement requirements are then stated in terms of the key operating parameters identified on p.12. (p.32)

KNOWLEDGE REQUIREMENTS LIST - The combined knowledge objectives list includes requirements from all mission categories. Many requirements pertain to more than one mission category. (p.33)

SPECTRAL SENSING PARAMETERS - Measurement requirements corresponding to key parameters on p.12 are coded to facilitate tabulation. (p.34)

SPECTRAL MEASUREMENT PARAMETERS VS. KNOWLEDGE REQUIREMENTS - Matrix intersections define measurement parameters. The complete table for 11 mission categories and 55 knowledge requirements appears in Appendix A. (p.35)

SPATIAL/TEMPORAL MEASUREMENT PARAMETERS - Measurement requirements corresponding to key parameters on p.12 are coded to facilitate tabulation. (p.36)

SPATIAL/TEMPORAL MEASUREMENT PARAMETERS VS. KNOWLEDGE REQUIREMENTS - Matrix intersections define measurement requirements. The complete table for 11 mission categories and 55 knowledge requirements appears in Appendix A. (p.37)

REQUIREMENTS DERIVATION

EARTH RESOURCES & ENVIRONMENTAL APPLICATION AREAS	e.g., Agriculture, Geological Resources
↓	
MISSION OBJECTIVES & SUB-OBJECTIVES	e.g., Predict Crop Yield
↓	
KNOWLEDGE REQUIREMENTS	e.g., Crop Identification, Plant Vigor
↓	
MEASUREMENT REQUIREMENTS	e.g., Resolution, Ground Coverage

KNOWLEDGE REQUIREMENTS LIST

1. VEGETATION IDENTIFICATION
2. VEGETATION AREAL EXTENT & DISTRIBUTION (MAPS)
3. PLANT DENSITY
4. PLANT SIZE OR STAGE OF DEVELOPMENT
5. PLANT VIGOR
6. PLANT RATE OF GROWTH
7. PLANT STRESS, DAMAGE & THEIR SOURCE
8. SOIL MOISTURE VS. DEPTH
9. METHOD OF CULTIVATION (E.G., IRRIGATION)
10. GRAZING INTENSITY
11. STANDING TIMBER PER SQUARE AREA
12. SURFACE TEXTURE - LAND
13. SOIL DENSITY, POROSITY
14. SOIL CHEMICAL COMPOSITION - SURFACE
15. SOIL CHEMICAL COMPOSITION vs. DEPTH
16. GEOTHERMAL SOURCES
17. FRESH WATER RESOURCES AREAL EXTENT & DEPTH DIST.
18. SNOW COVER
19. LOCATION & DISTRIBUTION OF BUILDING STRUCTURES
20. LOCATION & DISTRIBUTION OF ROADS & RAILWAYS
21. LAND TOPOGRAPHY
22. WATER-BODY CHEMICAL CONTENTS
23. PLANKTON DISTRIBUTION IN OCEANS
24. FISH LOCATION & DISTRIBUTION
25. FISHING PATTERNS
26. RED TIDES
27. ICE FORMATIONS LOCATION & AREAL/VOLUMETRIC SIZE
28. GLOBAL DISTRIBUTION OF TROPOSPHERIC GASES/AEROSOLS
29. POLLUTANT TRANSPORT MECHANISMS IN ATMOSPHERE
30. AIR POLLUTANT DISTRIBUTION IN ATMOSPHERE
31. OCEAN POLLUTION CONCENTRATIONS & DISTRIBUTION
32. OIL SPILL DETECTION AND AREAL EXTENT
33. POLLUTION DETECTION IN RIVERS AND LAKES
34. DISASTER PREDICTION - STORMS, FLOODS
35. DISASTER PREDICTION - TIDAL WAVES
36. DISASTER PREDICTION/ASSESSMENT - EARTHQUAKES
37. DISASTER DAMAGE TO STRUCTURES & FLORA
38. ATMOSPHERE TEMPERATURE VERTICAL PROFILE
39. CLOUD TEMPERATURE & LATENT HEAT
40. WATER SURFACE TEMPERATURE DISTRIBUTION
41. ATMOSPHERIC PRESSURE VERTICAL PROFILE
42. RATE OF EVAPORATION (SPATIAL DISTRIBUTION)
43. EARTH RADIATION DISTRIBUTION
44. SOLAR CONSTANT
45. WIND PROFILE & DIRECTION
46. SEA SURFACE WIND VELOCITY AND DIRECTION
47. WAVE CHARACTERISTICS
48. OCEAN CURRENT VELOCITY, RATE, AND COURSE
49. COASTAL ESTUARY CIRCULATION
50. COASTAL SHORELINE SHIFTS
51. EARTH CRUSTAL FAULTS
52. TECTONIC MOVEMENT
53. LITHOLOGICAL FEATURES OF EARTH
54. GEOLOGICAL STRUCTURE
55. GEO-MORPHOLOGICAL FEATURES

SPECTRAL/SENSING PARAMETERS

(1) SENSOR TECHNIQUE

M = MAPPER
M_S = STEREO MAPPER

M_P = POINTABLE MAPPER

M_{SP} = POINTABLE STEREO MAPPER

D = POINT DETECTOR, NADIR LOOKING
D_P = POINT DETECTOR, POINTABLE

S = SOUNDER
S_P = POINTABLE SOUNDER
S_L = LIMB SOUNDER
S_R = SOUNDER, RANGE & RANGE RATE

ALT = ALTIMETER
SC = SCATTEROMETER

(2) SPECTRAL REGION:

UV	f = FAR	RELATES TO UV, IR
VIS	n = NEAR	
IR		
MW	m = METRIC	
	d = DECIMETRIC	
	c = CENTRIMETRIC	
	mm = MILLIMETRIC	

(3) NO. OF CHANNELS: M = MANY (>9)
S = SEVERAL (4-9)
F = FEW (<4)

a = ACTIVE ILLUMINATION
p = PASSIVE ILLUMINATION

(4) SPECTRAL RESOLUTION (b/u): WIDE = W (>30 nm)
NARROW = N (<30 nm) (VIS-IR)
\- = NOT SIGNIFICANT OR RELEVANT

(1)	(2)	(3)	(4)
M_P	VIS	M_a	W

GENERAL ELECTRIC

space division

SPECTRAL MEASUREMENT PARAMETERS VS.
KNOWLEDGE REQUIREMENTS
(PARTIAL - SEE TABLE A-1)

KNOWLEDGE REQUIREMENTS \ STUDY DISCIPLINES	G ENVIRON. QUALITY	H DISASTER PRE-DICTION	I WEATHER & CLIMATE	J ATMOS-PHERE	K EARTH & OCEAN DYNAMICS
38. ATMOSPHERE TEMPERATURE VERTICAL PROFILE	S/IR/S/N	S/IR/S/N	S/IR/S/N	S/IR/S/N	
39. CLOUD TEMPERATURE & LATENT HEAT		M/IR/S/N	M/IR/S/N	M/IR/S/N	
40. WATER SURFACE TEMPERATURE DISTRIBUTION		M/IR/S/N	M/IR/S/N		
41. ATMOSPHERIC PRESSURE VERTICAL PROFILE		S/VIS,IR^A/S/N	S/VIS, IR^A/S/N	S/VIS^A, IR^A/S/N	
42. RATE OF EVAPORATION (SPATIAL DISTRIBUTION)		S/IR/S/N	S/IR/S/N		
43. EARTH RADIATION DISTRIBUTION		M/IR/F/W	M/IR/F/W		
44. SOLAR CONSTANT		D_P/IR/F/W	D_P/IR/F/W		
45. WIND PROFILE & DIRECTION	D/IR,MW/F/N	D/IR,MW/F/N	D/IR,MW/F/N	D/IR,MW/F/N	
46. SEA SURFACE WIND VELOCITY & DIRECTION	D/MW/F/N				SC/MW_C/F/-
47. WAVE CHARACTERISTICS					ALT/VIS,MW_C/F/-
48. OCEAN CURRENT VELOCITY, RATE, AND COURSE	M/VIS,IR/F/W				M/VIS,IR/F/W
49. COASTAL ESTUARY CIRCULATION					M/VIS,IR/F/W
50. COASTAL SHORELINE SHIFTS					M/VIS,IR/F/W
51. EARTH CRUSTAL FAULTS					M/MW/F/-

SPATIAL/TEMPORAL MEASUREMENT PARAMETERS

	CATEGORY	DESCRIPTION
1	SPATIAL RESOLUTION	H. HIGH: $<$ 10 METERS M. MEDIUM: 10 - 100 METERS L. LOW: $>$ 100
2	GROUND COVERAGE PER ORBIT (e.g., SWATH WIDTH)	L. LARGE: $>$ 1000 km I. INTERMEDIATE: 200 - 1000 km S. SMALL: $<$ 200 km
3	REPEAT CYCLE	EVERY N DAYS O. ONCE Y. YEARLY
4	TYPE OF SAMPLING	C. CONTINUOUS P. PERIODIC P_S PERIODIC SPOT P_A PERIODIC AREA

EXAMPLE:

1	2	3	4
M	L	18	P_S

SPATIAL/TEMPORAL MEASUREMENT PARAMETERS VS.
KNOWLEDGE REQUIREMENTS
(PARTIAL - SEE TABLE A-2)

STUDY DISCIPLINES / KNOWLEDGE REQUIREMENTS	A AGRICUL-TURE	B RANGE MGMT	C FORESTRY	D GEOLOG. RESOURCES	E LAND USE	F WATER RES. & OCEAN
1. VEGETATION IDENTIFICATION	M/L/90/C	M/L/90/C	M/L/Y/C	M/I/O/C	M/L/90/C	
2. VEGETATION AREAL EXTENT & DIST. (MAPS)	M/L/90/C	M/L/90/C	M/L/Y/C		M/L/90/C	
3. PLANT DENSITY	M/I/15/Pa	M/L/Y/C				
4. PLANT SIZE OR STAGE OF DEVELOPMENT	M/I/15/Pa	M/I/15/Pa	M/L/Y/C			
5. PLANT VIGOR	M/I/15/Pa	M/I/15/Pa	M/I/Y/Pa			
6. PLANT RATE OF GROWTH	M/I/15/Pa	M/I/15/Pa	M/I/90/Pa			
7. PLANT STRESS, DAMAGE & THEIR SOURCE	M/L/15/C	M/L/15/C	M/I/90/Pa			
8. SOIL MOISTURE vs. DEPTH	M/L/15/C	L/L/15/C	L/L/30/C			
9. METHOD OF CULTIVATION (e.g., IRRIGATION)	L/I/Y/Pa				L/I/Y/Pa	
10. GRAZING INTENSITY		H/I/60/Pa				
11. STANDING TIMBER PER SQUARE AREA			M/I/Y/Pa		M/I/Y/Pa	
12. SURFACE TEXTURE - LAND				M/I/O/C		
13. SOIL DENSITY, POROSITY				M/I/O/C		
14. SOIL CHEMICAL COMPOSITION - SURFACE	L/L/O/C	L/L/O/C	L/L/O/C	M/I/O/C		
15. SOIL CHEMICAL COMPOSITION vs. DEPTH	L/L/O/C	L/L/O/C	L/L/O/C	L/I/O/C		
16. GEOLOGICAL DEPOSITS/FORMATIONS				M/I/O/C		

III. CANDIDATE SENSORS (TASK 2)

Numerous sensor concepts for future earth resources and environmental applications have been suggested in studies such as PLACE and GSS Circa 1995. These concepts are used in the current study to form the basis for generic sensor categories whose performance spans the full range of the key operating parameters.

SENSOR CONCEPTS

PRELIMINARY SENSOR CONCEPTS - A variety of sources provide preliminary sensor concepts. (p. 41)

SENSOR CONCEPTS AND CHARACTERISTICS - Each sensor is analyzed for key spatial and spectral operating parameters. Complete tables for active and passive, optical and microwave sensors appear in Appendix A. (p.42)

PASSIVE SENSORS - 28 generic passive optical and microwave sensors are derived from the preliminary sensor concepts (Nos. 1 - 28). (p.43)

ACTIVE SENSORS - 18 generic active optical and microwave sensors are derived from the preliminary sensor concepts (Nos. 30-47). (p.44)

SPECIAL SENSORS AND CHARACTERISTICS - Special sensors include data collection platforms, field sensors, and particle/plasma sensors. Specific performance values are TBD at this time. (p.45)

PRELIMINARY SENSOR CONCEPTS
(SEE TABLES A-3 AND A-4)

- ACTIVE AND PASSIVE TYPES
- LOW EARTH THROUGH GEOSYNCHRONOUS
- EXISTING, PROPOSED, OR CONCEPTUALIZED (VIABLE IN THE 1990-95 TIME FRAME)
- STUDY SOURCES:
  - JPL GSS STUDY (VOL. II)
  - GE PLACE STUDY
  - MSFC REMOTE SENSING DATA HANDBOOK
  - GE SEOPS STUDY
  - GE EVAL (SPACELAB) STUDY
  - LIDAR SEED DOCUMENT
- CURRENT/PLANNED SPACECRAFT PROGRAMS:

  NIMBUS — SEASAT

  LANDSAT — TIROS

  DMSP (DEFENSE METEOROLOGICAL SATELLITE PROGRAM)

  HCMM (HEAT CAPACITY MAPPING MISSION)

  ERBSS (EARTH RADIATION BUDGET SATELLITE SYSTEM)

GENERAL ELECTRIC

SENSOR CONCEPTS AND CHARACTERISTICS - OPTICAL AND SHORTER WAVELENGTHS

space division

PASSIVE

	GAMMA RAY DETECTOR	X-RAY DETECTOR	UV MAPPER				MAPPER													STEREO MAPPER
	GAMMA RAY DETECTOR (1,2)	X-RAY DETECTOR (3,4,5)	UV COMP.(6)	SBUV(6)	ERB (7)	SSD (SOUNDER)(6)	SURF. FEATURE(9)	SURF. COMP. (10)	THERMAL/CLOUD(11)	RADIATION BUDGET (7)	VISIBLE GLITTER (7)	CFPA (12)	LANDSAT-H (9)	CZCS (10,11)	ERB (7,8)	TM (9)	RBV (7)	TH INERTIA MPPR (15)	HETERODYNE INTERFER. (14)	STEREO MAPPER (16)
FOV:																				
NARROW 100 KM												X								
MEDIUM 100-999						X	X				X		X			X	X	X		X
WIDE 1000	X	X	X	X	X			X	X	X				X	X				X	
FREQ BANDS:																				
MANY (> 9)				X	X		X	X		X	X		X		X				X	
SEVERAL (4-9)			X						X			?		X		X				
1 - 3	X	X				X											X	X		X
WIDTH OF BANDS:																				
NARROW (< 30 nm)	X	X	X	X		X	?	?	?	?	X	?	?	X		X	X	?	X	?
WIDE (>30 nm)					X										X					
SPATIAL RESOLUTION:																				
COARSE (> 100 nm)			X	X	X				X	X				X	X				X	
MEDIUM (10 n 100 m)	?	?				X		X			X					X	X			
FINE (<10 nm)							X					X	X					X		X
POINTING:																				
NADIR	?	?	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X
OFF-NADIR (INCLUDES POINTABLE)					X															
-LIMB						X														

PASSIVE SENSORS

NO.	TYPE	SENSOR	SOURCE
1	γ-RAY	SCINTILLATION COUNTER	STANDARD CONCEPTS
2	"	CHERENKOV COUNTER	
3	X-RAY	SCINTILLATION COUNTER	
4	"	PROPORTIONAL COUNTER	
5	EUV	WINDOWLESS PHOTOTUBE	
6	UV	COMPOSITION MAPPER	N, JPL
7	UV/VISIBLE/IR	ERB MAPPER	N, JPL, E
8		SOLAR STELLAR OCCULTATION	N
9		SURFACE FEATURES MAPPER	L, JPL, PLACE
10		SURFACE COMPOSITION MAPPER	N, JPL
11		THERMAL/CLOUD MAPPER	H, N, D, PLACE, T, JPL
12		CID FOCAL PLANE ARRAY	PLACE
13		FILM CAMERA MAPPER	STANDARD CONCEPT
14		INTERFEROMETRIC SPECTRUM MAPPER	SEOPS (CIMATS)
15		THERMAL INERTIA MAPPER	H, PLACE
16		STEREO MAPPER	JPL, STANDARD CONCEPT
17		POINTABLE IMAGER	PLACE, RSDH, STANDARD CONCEPT
18		LIMB SOUNDER	N, JPL
19		IR ATMOSPHERIC SOUNDER	T, N, JPL
20	MM WAVE	SURFACE MAPPER	N, D, JPL
21	μ WAVE	HIGH RESOLUTION IMAGER	S, N, D, T
22		SWEPT FREQUENCY SURFACE MAP	S, N, D, JPL
23		SURFACE MAPPER	S, N, D, T, JPL
24		MICROSAT	PLACE
25		LOW FREQUENCY MAPPER	N, JPL, SEOPS
26		LOW FREQUENCY MAPPER	N, JPL, SEOPS
27		ATMOSPHERIC SOUNDER	JPL, RSDH, SEOPS
28		LIMB SOUNDER	JPL
29	MM WAVE	ATMOSPHERIC SOUNDER	JPO, RSDH, SEOPS

ACTIVE SENSORS

NO.	TYPE	SENSOR	SOURCE
30	X-RAY	UPPER ATMOSPHERIC PROBE	GE CONCEPT
31	UV/VISIBLE/IR	SURFACE COMP LIDAR MAPPER	JPL, SEOPS
32		LANDSAT H NITE-LITE MAPPER	PLACE
33		LASER ALTIMETER	JPL, SEOPS
34		LASER SCATTEROMETER	JPL, SEOPS
35		LIDAR LUMINESCENCE DETECTOR	PLACE
36		TRACE SPECIES SOUNDER	SEED
37		PULSED LIDAR ATMOS. SOUNDER	JPL, SEED
38		CID LIDAR ATMOS. SOUNDER	JPL, SEED
39		OCEAN THERMAL LIDAR MAPPER	JPL
40	μ WAVE	REAL APERTURE RADAR SYSTEMS (BISTATIC, RAIN, WAVE SPECTRA, DOPPLER, PRESSURE, MHz)	SEOPS, JPL, STANDARD CONCEPTS
41		SCATTEROMETER RADAR	S, JPL, SEOPS
42		RADAR ALTIMETER	S, JPL, SEOPS
43		SWEPT FREQUENCY RADAR	SEOPS, JPL
44		POLYCHROMATIC MW SCATTEROMETER	EVAL
45		SAR	S, PLACE, SEOPS, JPL
46		SWEPT FREQUENCY SAR	PLACE
47		GEOSAR	PLACE

"SPECIAL" SENSORS AND CHARACTERISTICS

- DATA COLLECTION PLATFORMS
  - MAY INCLUDE AMBIENT MEASUREMENTS, SOUNDINGS, ETC., TELEMETERED TO SPACE PLATFORM
- FIELD MEASUREMENTS
  - GRAVITATIONAL FIELD
    - EVOLUTIONARY DEVELOPMENTS SUCH AS ROTATING GRAVITY GRADIOMETER
    - LASER POSITION DETERMINATION WILL IMPROVE CAPABILITY BY CORRELATIVE SUPPORT
  - MAGNETIC FIELD
    - EVOLUTIONARY DEVELOPMENTS SUCH AS FLEXGATE MAGNETOMETER
    - FAR-TERM POSSIBILITIES SUCH AS DOUBLE-RESONANCE MAGNETOMETER (FRENCH CONCEPT)
- PARTICLE/PLASMA MEASUREMENTS
  - NOT EARTH SENSING BUT SOME EARTH APPLICATIONS, e.g. SOLAR FLARE ACTIVITY SENSING VIA RESULTANT PARTICLES.
  - APPLICATIONS IN EARTH'S ELECTRICAL AND MAGNETIC FIELDS DEPENDENT ON ALTITUDE AND INCLINATION.

SENSOR CATEGORIES

SENSOR CATEGORIZATION - Measurement requirements and sensor performance are compared in the spectral and spatial areas. Categories are sized according to measurement demands and performance availabilities. (p.47)

SPECTRAL PERFORMANCE - Spectral measurement requirements are compared with generic sensor concepts to determine sensor spectral performance categories. (p.48)

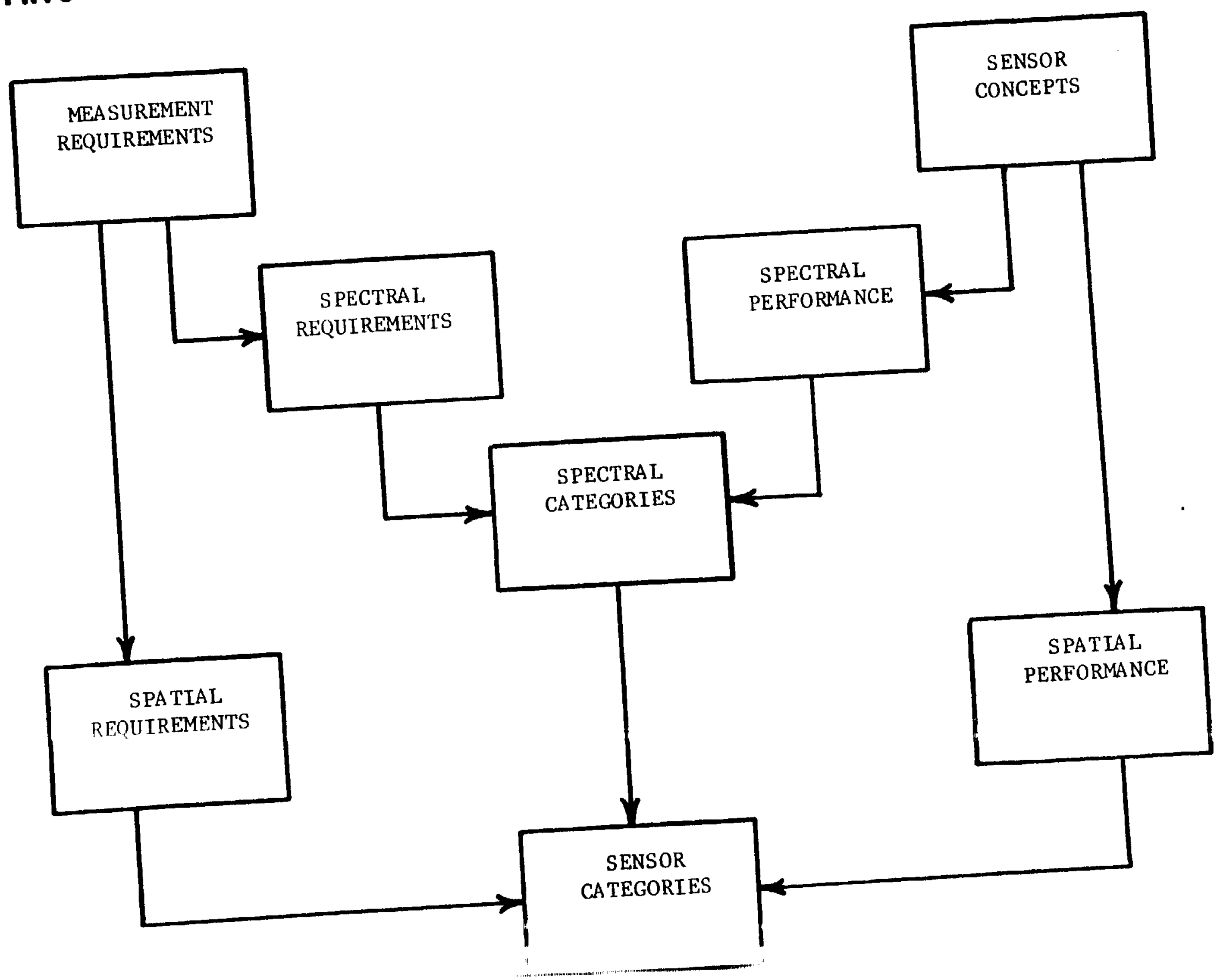
SPATIAL PERFORMANCE - Spatial measurement requirements are compared with generic sensor concepts to determine sensor spatial performance categories. (p.49)

SENSOR CATEGORIES - 38 generic sensor categories are identified. (p.50)

SENSOR CATEGORIES-OPTICAL AND SHORTER - The spectral and spatial performance of each sensor category is defined and specific sensor concepts are identified. Significant performance advances needed are identified where appropriate. (p.51)

SENSOR CATEGORIES-MICROWAVE AND SPECIAL - The spectral and spatial performance of each sensor category is defined and specific sensor concepts are identified. Significant performance advances are identified when appropriate. (p.52)

SENSOR CATEGORIZATION



SPECTRAL PERFORMANCE

SENSOR TYPE	BANDWIDTH	γ/X-RAY M	γ/X-RAY S	γ/X-RAY F	UV M	UV S	UV F	VIS-IR M	VIS-IR S	VIS-IR F	EMITTED IR M	EMITTED IR S	EMITTED IR F	MW (mm-cm) M	MW (mm-cm) S	MW (mm-cm) F	MW (dm-m) M	MW (dm-m) S	MW (dm-m) F
DETECTOR/ SCATTEROMETER	N			3			(2)						4		2	5			
	W						(2)						2		2	1			
MAPPER	N				(1)	(1)		8 (10)	25 (5)	(5)		5 (1)	(1)	1 (3)	3 (3)	3 (7)	3 (2)	3 (3)	5 (9)
	W				(1)			(6)	2 (3)	8 (4)		(1)	4 (1)	(2)	3 (2)	3 (2)	3 (1)	3 (2)	5 (3)
SOUNDER/ ALTIMETER	N						(1)	2 (5)	1 (3)	8 (5)	5 (1)	1		2 (2)	0 (6)	1 (1)		(2)	(1)
	W								(2)	(2)			1		1	1			

MEASUREMENT REQUIREMENTS: X

SENSOR CONCEPTS: (Y)

CHANNELS *
M=Many
S=Some
F=Few

BANDWIDTH *
N=Narrow
W=Wide

* See page 42

SPATIAL PERFORMANCE

SENSOR TYPE	SPATIAL RESOLUTION \ POINTING / FOV	NADIR N	NADIR M	NADIR W	OFF NADIR N	OFF NADIR M	OFF NADIR W	LIMB N	LIMB M	LIMB W	POINTABLE N	POINTABLE M	POINTABLE W
DETECTOR/ SCATTEROMETER	C		(1)										
	M		2 (3)	4		(1)							
	F												
MAPPER	C		3 (3)	21 (12)		3	21 (5)					2 (1)	3 (1)
	M		6 (4)	26 (1)		6 (1)	26 (2)					10 (1)	
	F	1 (1)	4 (4)	1	1	4 (3)	1 (1)				(2)		
SOUNDER/ ALTIMETER	C	(3)	1 (2)	11	(3)	1 (2)	11		(1)	8			
	M	(4)	(3)	5 (4)	(4)	(3)	5 (4)		(2)	(1)			(2)
	F	(4)	2 (2)	(1)	(4)	2 (2)	(1)	(1)	(2)				

MEASUREMENT REQUIREMENTS: X

SENSOR CONCEPTS: (Y)

FOV *
N=Narrow
M=Medium
W=Wide

SPATIAL RESOLUTION *
C=Coarse
M=Medium
F=Fine

* See page 42

GENERAL ELECTRIC

space division

SENSOR CATEGORIES

	GAMMA-RAY	X-RAY / EUV	UV	VISIBLE	IR	MICROWAVE	RF
PASSIVE	• X-RAY DETECTOR	• X-RAY DETECTOR • EUV DETECTOR	• UV MAPPER • UV SOUNDER	• HI RES. SPECTRAL MAPPER • WIDE FIELD SPECTRAL MAPPER • STEREO MAPPER • HI RES POINTABLE MAPPER • WIDE FIELD POINTABLE MAPPER • LIMB SOUNDER • VERTICAL SOUNDER	• IR MAPPER • IR SOUNDER • IR DETECTOR • IR POINTABLE DET	• MW LIMB SOUNDER • MW VERTICAL SOUNDER • MW DETECTOR • MMW SURFACE MAPPER • MW MAPPER	• LOW FREQUENCY MAPPER
ACTIVE				• LIDAR MAPPER • LIDAR SPECTROMETER • LIDAR SOUNDER • LASER ALTIMETER • LASER SCATTEROMETER • LASER SOUNDER		• MW SCATTEROMETER • RADAR MAPPER • RADAR ALTIMETER • RADAR SOUNDER • SAR	• MH_z RADAR SOUNDER
AL	• PARTICLE/PLASMA SENSORS		• GRAVITY FIELD SENSORS	• MAGNETIC FIELD SENSORS			• DOPs

SENSOR CATEGORIES - OPTICAL & SHORTER

CATEGORY	SPECTRAL PERF.*			SPATIAL PERF.*			SENSOR CONCEPTS	PERFORMANCE ADVANCE
	REGIME	CH.	B.W.	PT.	FOV	RES		
γ-RAY DETECTOR	γ-RAY	S	W	N/L	W/M/N	C	SCINT CT, CER CT(1,4)	BASIC TECHNOLOGY
X-RAY DETECTOR	X-RAY	S	W	N/L	W/M/N	C	SCINT CT, PROP CT [illegible]	
EUV DETECTOR	EUV	S	W	N/L	W/M/N	C	WINDOWLESS PHOTOTUBE 5)	
UV MAPPER	UV	M	W/N	N	W	C	UV COMP MAP, ERB [illegible]	
UV SOUNDER	UV	F	N	L	M	M	SOL STEL OCC(8)	
HI RES SPECTRAL MAPPER	VIS-IR	M	W/N	N	M	F	SURF FEAT, FILM CAM (9,13)	HI RESOLUTION
WIDE FIELD SPECTRAL MAPPER	VIS-IR	M/S	W/N	N	W/M	C/M	SURF. COMP. (10)	
STEREO MAPPER	VIS-IR	F	W/N	N	M	M/F	STEREO MAPPER (16)	HI RESOLUTION
HI RES POINTABLE MAPPER	VIS-IR	M/S	W/N	P	N	F	CFPA (12)	CIS ARRAY
WIDE FIELD POINTABLE MAPPER	VIS-IR	M/S	W/N	P	W/M	C	POINTABLE IMAGER ([illegible])	
LIMB SOUNDER	VIS-IR	M/S/F	W/N	L	M	M/F	LIMB SOUNDER (13)	
VERTICAL SOUNDER	VIS-IR	M	N	N	W	M	INT. SPECT. SOUNDER (14)	
IR MAPPER	IR	S/F	W/N	N	W/M	C/M/F	TH CLOUD, TH INERT (11,15)	DETECTOR TECHNOLOGY
IR SOUNDER	IR	M/S/F	W/N	N	W	M/F	IR ATMOS (19)	
IR DETECTOR	IR	F	W/N	N	W	M	————	
IR POINTABLE DETECTOR	IR	F	W/N	P	W	C	————	
LIDAR MAPPER	VIS-IR	F	W/N	N	M	C/M/F	NITE LITE (32)	OPTICAL SYSTEMS
LIDAR SPECTROMETER	VIS-IR	M	W/N	N	N	M	SURF COMP (31)	
LIDAR SOUNDER	VIS-IR	M/S/F	W/N	N	M/N	C/M/F	PULSED ATMOS, CW ATMOS, OCEAN.THERM (37,38,39)	
LASER ALTIMETER	VIS-IR	F	W/N	N	N	F	LASER ALTIMETER (33)	
LASER SCATTEROMETER	VIS-IR	F	W/N	N	M	C	LASER SCAT, LUM DET (34,35)	
LASER SOUNDER	VIS-IR	M	W/N	SAT	N	F	TRACE SPECIES (36)	

* See p. 34. 36.

SENSOR CATEGORIES - MICROWAVE AND SPECIAL

CATEGORY	SPECTRAL PERF. *			SPATIAL PERF. *			SENSOR CONCEPTS	PERFORMANCE IMPROVEMENTS
	REGIME	CH.	B.W.	PT.	FOV	RES		
MMW SURFACE MAPPER	MW_H	M	W/N	N	W	M	MMW SURFACE MAPPER, HI RES MW IMAGER(20,21)	LARGE STRUCTURES (ANTENNAS)
MW MAPPER	MW_{HL}	M/S/F	W/N	N	W/M	C	SWEPT FREQ SURF MAP, MW SURFACE MAPPER(22,23)	
MW LIMB SOUNDER	MW_H	M	N	L	W	M	MW LIMB SOUNDER(28)	
MW VERTICAL SOUNDER	MW_H	M/S/F	W/N	N	W/M	C/M	MMW ATMOS SOUNDER, MW ATMOS SOUNDER(29,27)	
MW DETECTOR	MW_H	F	N	N	W	M	--	
LOW FREQUENCY MAPPER	MW_L	F	W/N	N	W/M	C/M	LOW FREQUENCY MAPPER, MICROSAT (24,25)	
MW SCATTEROMETER	MW_H	S/F	W/N	N	M	C/M	SCAT RADAR (41)	LARGE STRUCTURES (ANTENNAS)
RADAR MAPPER	MW_{HL}	M/S/F	W/N	O	W/N	C/M	REAL APERTURE RADAR MAP, SWEPT FREQ RADAR(40,43)	
RADAR ALTIMETER	MW_{HL}	S	N	N	N	F	RADAR ALTIMETER(42)	
RADAR SOUNDER	MW_{HL}	S	N	O/N	W/M/N	C	PRES RADAR, RAIN RADAR(40)	
SAR	MW_{HL}	M/S/F	W/N	O	W/M	M/F	SAR, SWEPT FREQ SAR, GEOSAR (45,46,47)	
MH_2 RADAR SOUNDER	MW_L	F	N	N	M	M	POLY MW SCAT(44)	
DCP's	RF	M	N	P	N	F	AMPA	BASIC TECHNOLOGY
GRAVITY FIELD SENSORS	GRAV	F	W	S	W	C	--	
MAGNETIC FIELD SENSORS	MAG	F	W	S	W	C	--	
PARTICLE/PLASMA SENSORS	PART/PLAS	M/S/F	W/N	S	W	C	--	

* See p. 34, 36.

IV. OPERATING REQUIREMENTS (TASK 3)

Remote sensing in the 1990s will involve simultaneous observation of target areas using a number of sensors operating in a wide variety of spectral bands, plus a temporal component provided by timely repeat observation in certain measurement areas. Pixel-to-pixel correlation of simultaneous and non-simultaneous measurements will be important. In this way both spectral and temporal signatures will be used to identify observed properties and phenomena.

A first approximation of the range of measurements to be made on a mission is obtained by identifying the generic sensors that meet primary mission objectives and can compatibly operate on the same platform or platform set. To aid in this identification, a matrix of sensor operating requirements is developed. This matrix includes quantitative data where possible and qualitative data when necessary.

REMOTE SENSING AND OPERATING REQUIREMENTS

A possible analog for future operational remote sensing is found in the retinex theory of vision. It is presented here as a philosophical baseline used to establish sensor operating requirements.

RETINEX THEORY OF VISION - As advanced by Edwin H. Land of Polaroid Corporation, the retinex theory explains the human eye's power to accurately perceive color under a wide range of lighting conditions. The eye first determines "lightness" values for monochromatic images in each of three spectral areas served by cone pigments in the retina, then combines the three images into a full color image. The "lightness"values are established without recourse to a calibration standard and are corrected for gradations in illumination across the scene. The exact mechanism for "lightness" determination is not fully understood. (p.55)

REMOTE SENSING IN THE 1990s - By analogy to the retinex theory, future remote sensing systems can be expected to make use of selective processing of multi-spectral data to see the "colors" that provide information required by the user. Hence, platforms that allow simultaneous viewing of target areas by many sensors would seem desirable. A presently undefined property of future sensors would be the ability to self-calibrate in the individual spectral areas. (p.56)

Data needed for mission compatibility, operating compatibility, and mission feasibility assessments in subsequent tasks is generated and collected in a matrix.

REQUIREMENTS MATRIX - Each generic sensor category is related to measurement requirements and mission requirements in a large matrix that also defines orbit parameters, sensor operations, and accommodation requirements. Orbit, operation, and accommodation data were determined from mission requirements and sensor descriptions, using subjective judgment where necessary. The matrix serves as a data base for mission/operation compatibility analyses and feasibility assessments. The complete matrix appears in Appendix A. (p.57)

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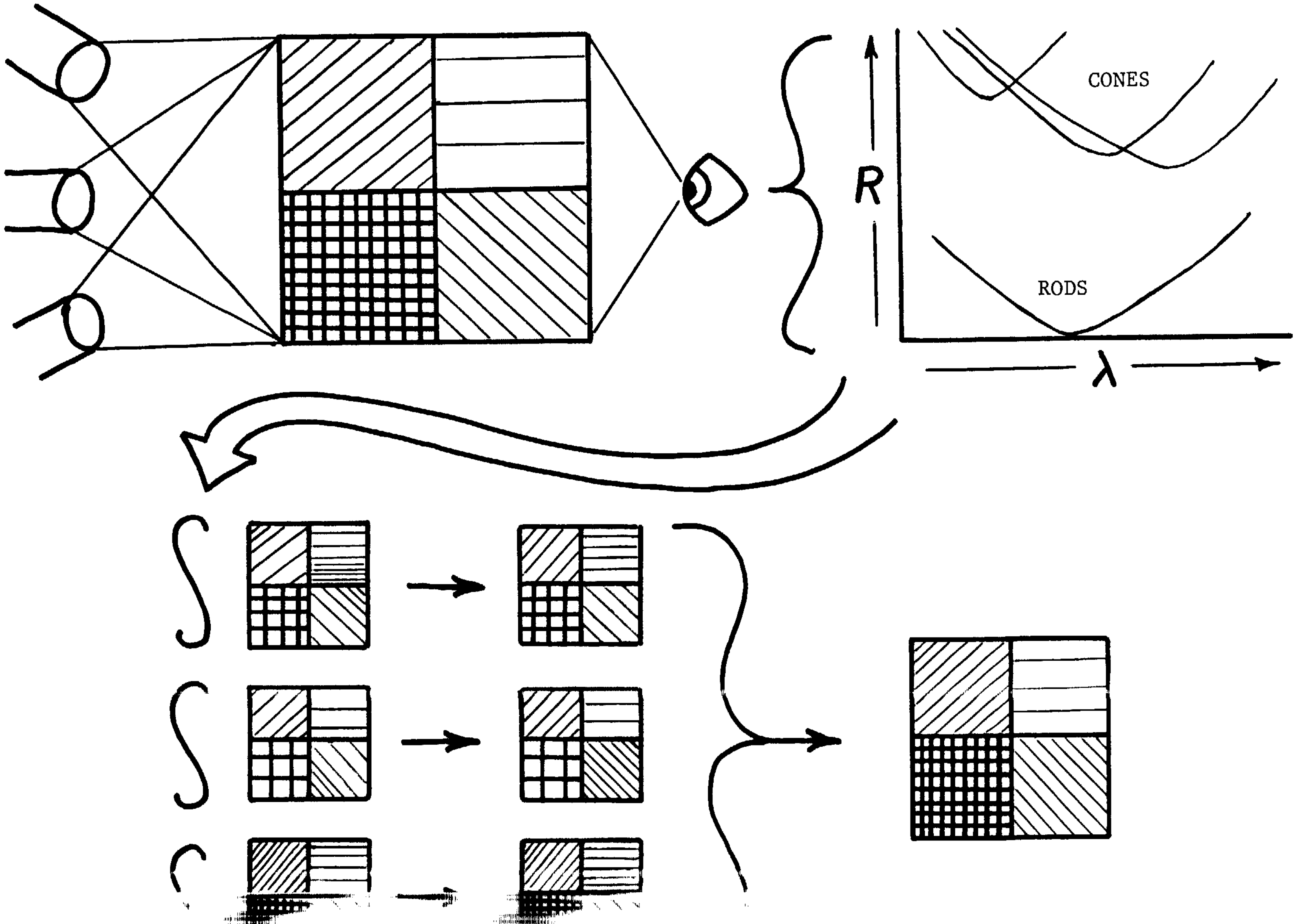
RETINEX THEORY OF VISION
(REFERENCE 9)



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REMOTE SENSING IN THE 1990's

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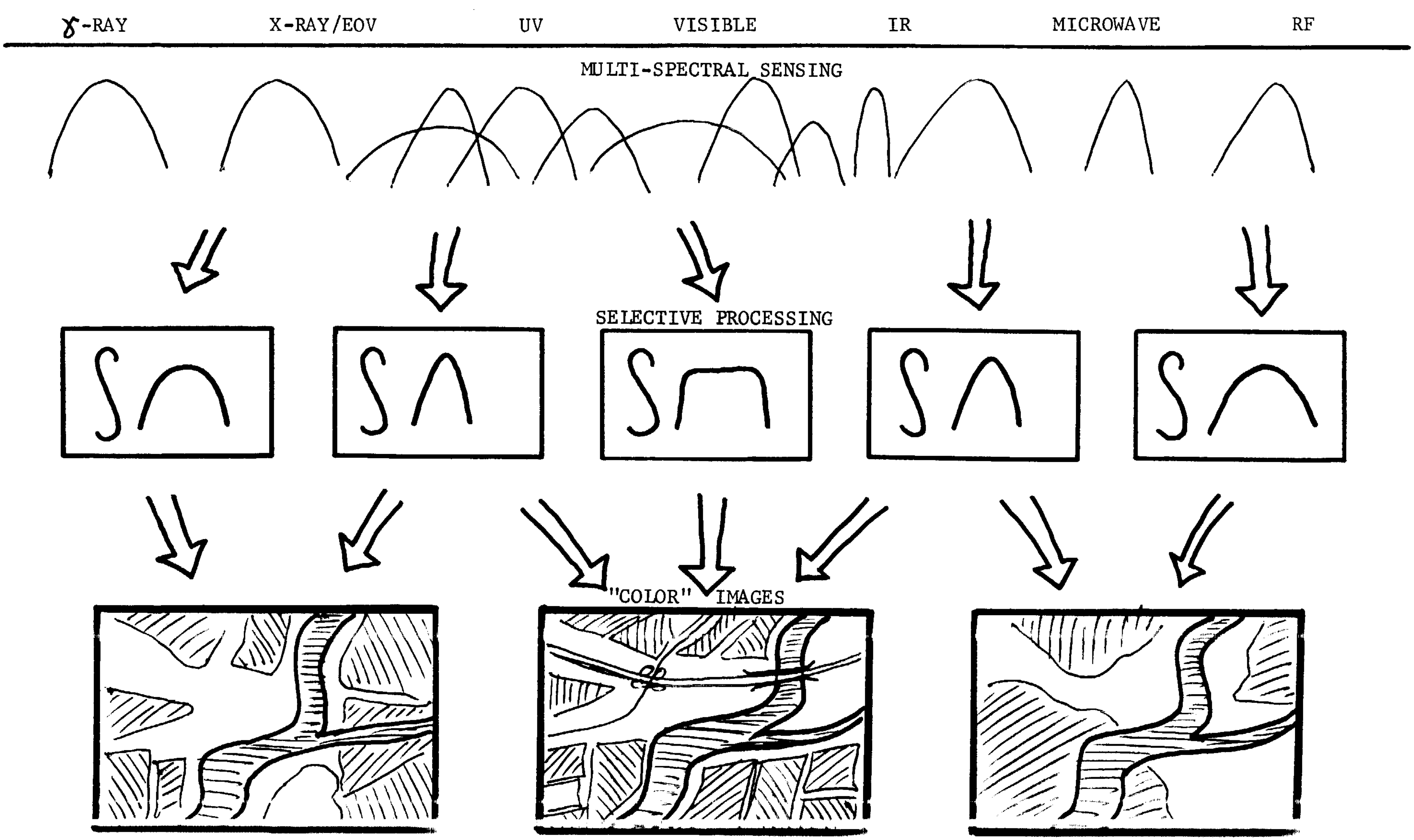


REQUIREMENTS MATRIX
(See Table A-5 for Full Matrix
and Parameter Definition)

ALT	INC	NODE TIME	PREL CYCLE	DUTY CYCLE	VIEW	EMI	SAMPLE/SIZE	PWR	DATA	T.C.	STAB	SCAN TRACK	ILL	INST	MAINT.	REMARKS
L	S	AP	S	1/2	N	N	BOX/SMALL	N	H	N	N	NA	NA	U/D	N	

SENSOR TYPE	SPECTRAL PERF REGIME	SPECTRAL PERF CH	SPECTRAL PERF B.W.	SPATIAL PERF PT.	SPATIAL PERF FOV	SPATIAL PERF RES	MEAS. REQ'T	MISSION REQ'TS TOT	MISSION REQ'TS RPT	MISSION REQ'TS COV	LIGHT SUN L	OBLIQ
HI RES SPEDT MAP	VIS-IR	M	W/N	N	M	F	32-G 33-G	T	1	C	D_T	OK
WIDE FIELD SPECT MAP	VIS-IR	M/S	W/N	N	W/M	C/M	1-D 15-D	W	0	C	D_T	OK
							22-F 23-F	W	5	C		
							24-F 26-F 31-F	W	1	C		
							14-ABC	T	O	C		
							1-C 2-C	T	Y	C		
							1-AB 2-AB	T	90	C		
							7-C	T	90	P		
							8-C	T	30	C		

V. MISSION COMPATIBILITY (TASK 4)

Mission compatibility establishes the capability of a given sensor to satisfy its measurement requirements in a variety of operating orbits. Key parameters include altitude, inclination, repeat cycle, and lighting conditions. Candidate altitudes are low earth orbit (LEO), mid earth orbit (MEO), and geosynchronous earth orbit (GEO). Altitude primarily affects spatial resolution, field of view, and sensor sensitivity as a function of sensor size. Inclinations are polar, sun synchronous, inclined, and equational; inclination primarily affects extent of ground coverage. Repeat cycles of one day or more are possible at a variety of altitude/inclination combinations in LEO and MEO; GEO coverage is effectively a daily repeat. Lighting conditions vary from constant node time (sun synchronous) to daily repeat (geosynchronous) to long term variation over a precession cycle (inclined orbits).

For study purposes, LEO is considered to be less than 1100 nmi (~2000 km), and MEO is defined as 1100 to 5000 nmi (~2000 to ~10,000 km).

REPEAT CYCLES AND LIGHTING

REPEAT CYCLES - Ground coverage repeats when the swath pattern on day N equals the swath pattern on day 1. This occurs when an integral number of orbit revolutions (periods) takes an integral number of earth revolutions (days), corrected for orbit precession. Lighting conditions repeat when the node time on day N equals the node time on day 1. This occurs when the orbit has completed a precession cycle, subject to seasonal variations. (A sun synchronous orbit has an infinite solar inertial precession period, hence a constant node time.) (p.61)

REPEATING ORBITS (SUN SYNCHRONOUS) - Descrete altitude points yield repeating orbits with daily or multi-day repeat cycles. Points nearest to the zero drift lines provide regular swathing patterns. Other points result in leap-frogging swathing patterns. (For non-sun synchronous orbits the array of points moves to the left due to the effects of non-zero solar inertial orbit precession. (p.62)

DAYLIGHT COVERAGE - It is convenient to use a solar inertial base for determining lighting effects of orbit precession (a). With this base a sun synchronous orbit has zero precession rate, or an infinite precession period. Non-zero orbit precession results in changing sun angle at a given latitude, including periods of no sun at all. During each precession cycle of a LEO inclined orbit (b), there is a period of a few days to a few weeks when northern latitudes cannot be observed in daylight on either the ascending (up) or descending (down) pass. A similar situation occurs in the southern latitudes later in the cycle. Sun synchronous orbits (c) experience only seasonal variations over the course of a year. A GEO inclined orbit (d) experiences effects similar to a LEO inclined orbit, but on an annual cycle. Lighting effects on a GEO mission can be minimized by matching seasonal variations. Histories of ascending node lighting for three typical orbits are compared over a year's elapsed time (e). (p.63)

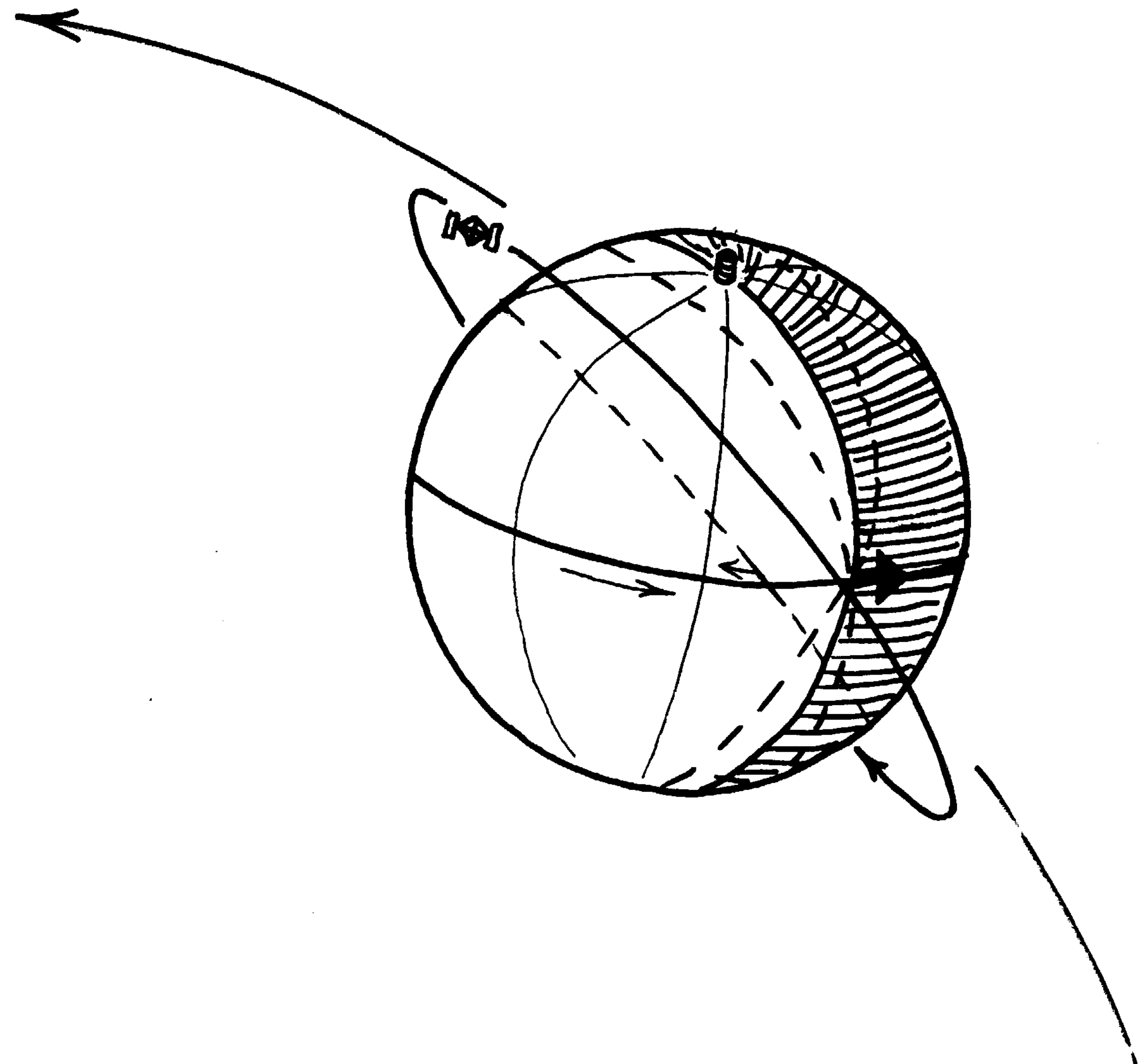
REPEAT CYCLES

COVERAGE

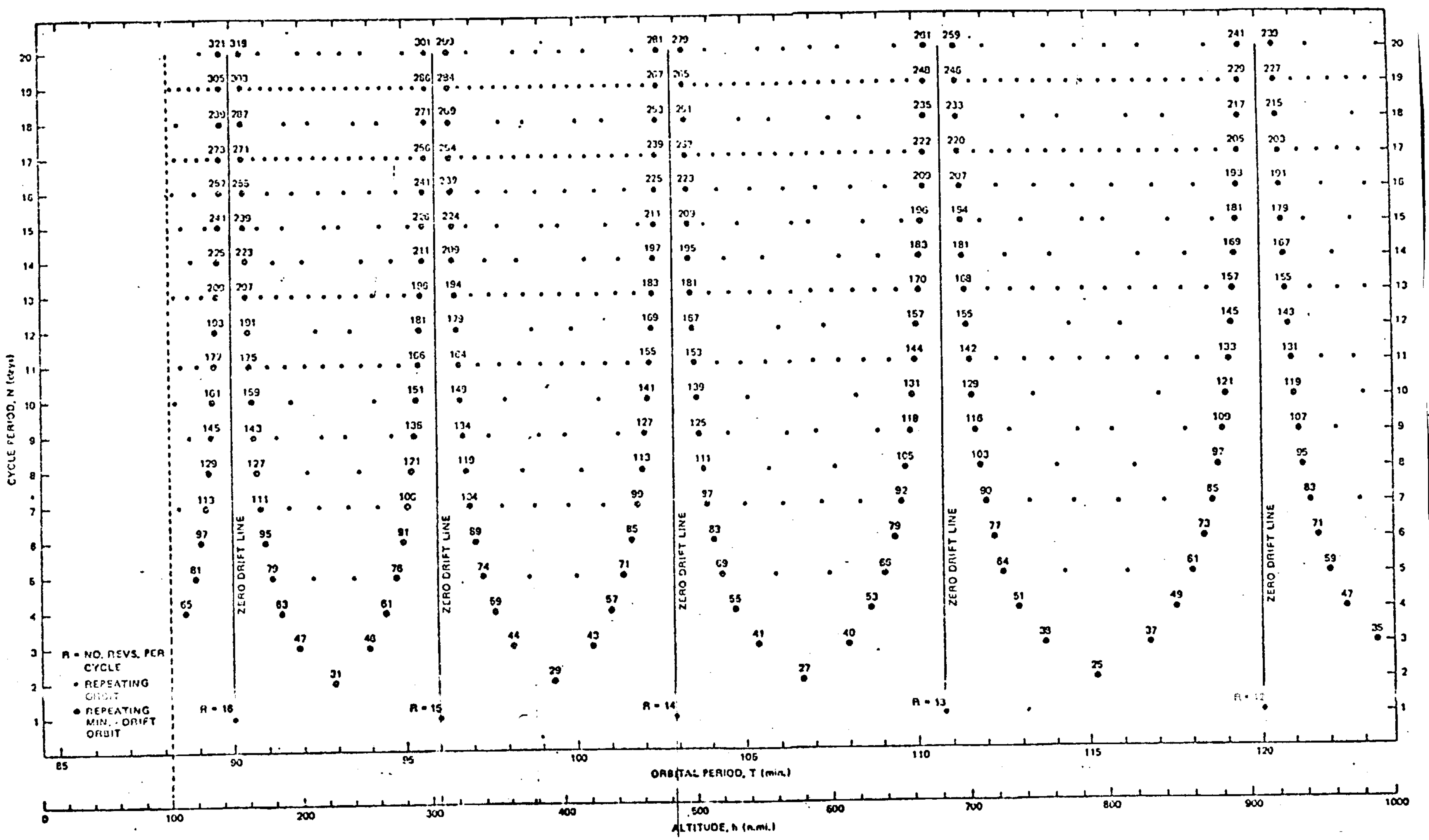
- SWATH PATTERN ON DAY N = SWATH PATTERN ON DAY 1

LIGHTING

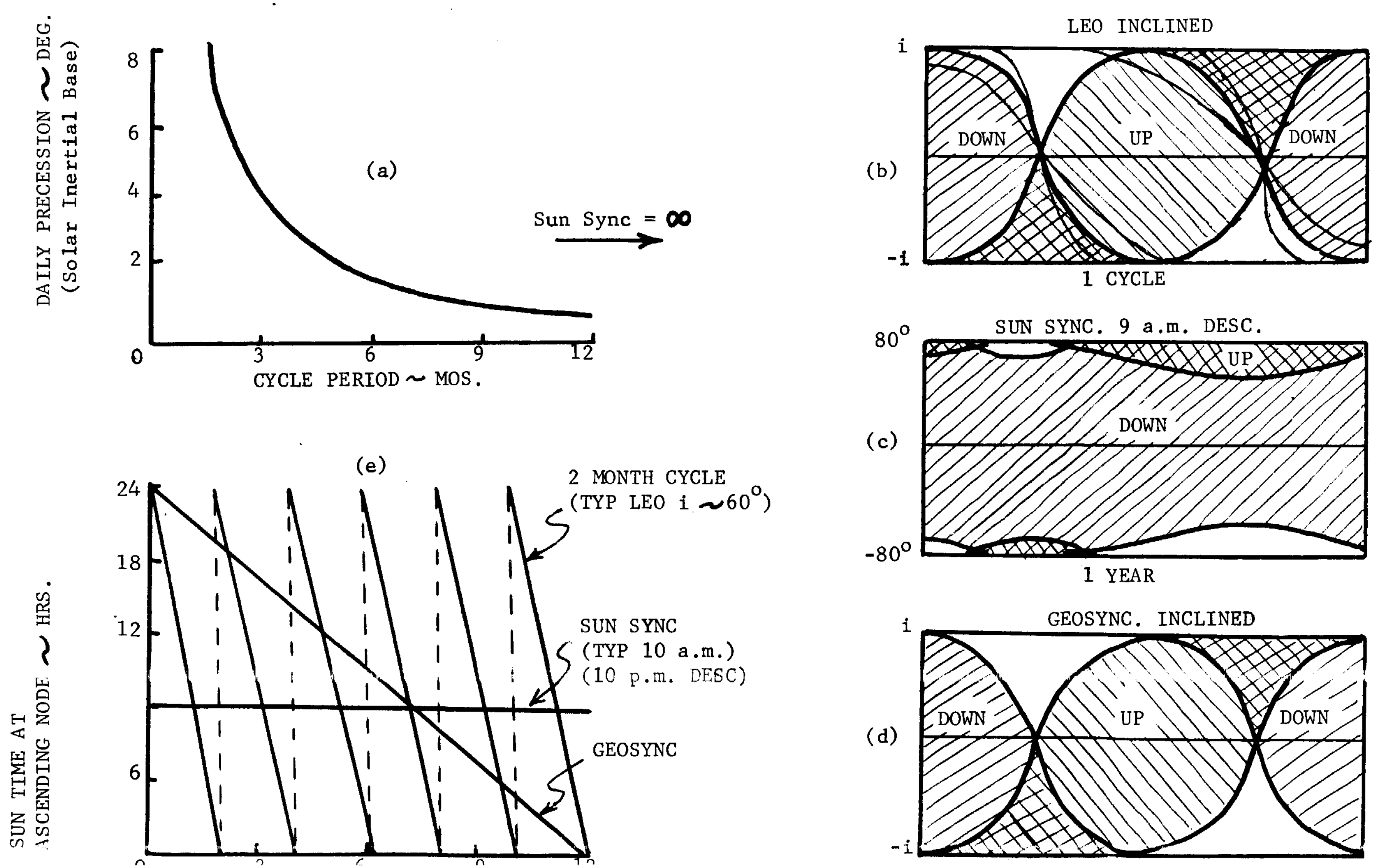
- NODE TIME ON DAY N = NODE TIME ON DAY 1



REPEATING ORBITS
(SUN SYNCHRONOUS)
(REFERENCE 6)



DAYLIGHT COVERAGE



ORBIT COMPATIBLE SENSORS

ORBIT GROUPS - Sensors are matched to seven altitude/inclination combinations, according to the orbit and lighting requirements shown in Table A-5 (columns 5, 7-10). (p.65)

SUN SYNCHRONOUS SENSORS - Ten sensors prefer sun synchronous orbits, either for constant lighting conditions or to complement sensors that require constant lighting conditions. (p.66)

POLAR ORBIT SENSORS - Thirteen sensors that provide whole earth coverage and are not sensitive to lighting conditions can utilize polar orbits. These include five sensors without specific mission requirements. (p.67)

INCLINED ORBIT SENSORS - Twenty-three sensors that provide less than whole earth coverage can utilize inclined orbits. In the case of sensors with specific lighting requirements, more than one platform may be required. Five sensors without specific mission requirements are included. (p.68)

GEO-SYNCHRONOUS SENSORS - Three sensors that can operate at geo-synchronous altitudes are identified. (p.69)

DAILY REPEAT REQUIREMENTS - Multiple platforms are required for daily coverage if medium or high resolution coverage is required, or if both morning and afternoon coverage is required. (p.70)

ORBIT GROUPS

SUN SYNCHRONOUS: PASSIVE OPTICAL SENSORS

LEO: HIGH RESOLUTION MAPPERS; WIDE FIELD MAPPERS, SOUNDERS, DETECTORS

MEO: WIDE FIELD MAPPERS, SOUNDERS, DETECTORS

POLAR: ACTIVE OPTICAL SENSORS, ACTIVE AND PASSIVE MICROWAVE SENSORS

LEO: HIGH RESOLUTION MAPPERS, ALTIMETERS, SCATTEROMETERS, SOUNDERS; WIDE FIELD MAPPERS, SOUNDERS, DETECTORS

MEO: WIDE FIELD MAPPERS, SOUNDERS, DETECTORS

INCLINED: ACTIVE AND PASSIVE OPTICAL SENSORS, ACTIVE AND PASSIVE MICROWAVE SENSORS

LEO: HIGH RESOLUTION MAPPERS, ALTIMETERS, SCATTEROMETERS, SOUNDERS; WIDE FIELD MAPPERS, SOUNDERS

MEO: WIDE FIELD MAPPERS, SOUNDERS

GEOSYNCHRONOUS: GEOS TYPE OPTICAL SENSORS, MMW MAPPER AND SOUNDER, GEO SAR

SUN SYNCHRONOUS SENSORS

SENSOR	ALTITUDE	NODE TIME	REPEAT CYCLE (DAYS)	COVERAGE
HI RESOLUTION SPECTRAL MAPPER	L	A/P	1	C
WIDE FIELD SPECTRAL MAPPER	L/M	A/P	1/15/30/90	C/P
	L/M	A & P	0.5	C
STEREO MAPPER	L/M	A/P	1/15/90	C
HI RESOLUTION POINTABLE MAPPER *	L	-	60	P
VIS-IR LIMB SOUNDER	L/M	M & E	0.5	C
VIS-IR VERTICAL SOUNDER *	L/M	-	0.5	C
IR MAPPER *	L/M	-	0.5/1	CS
IR SOUNDER *	L/M	-	0.5/1	CS
IR DETECTOR *	L/M	-	0.5/1	P
IR POINTABLE DETECTOR *	L/M	-	1	S

* NEED FOR SUN SYNCHRONOUS ORBIT NOT FIRMLY ESTABLISHED; WOULD APPEAR DISIREABLE.

L = LOW EARTH ORBIT
M = MID EARTH ORBIT
A = A.M.
P = P.M.

M & E = MORNING AND EVENING
C = CONTINUOUS COVERAGE
P = PARTIAL COVERAGE
S = SPOT COVERAGE

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POLAR ORBIT SENSORS

SENSOR	ALTITUDE	NODE TIME	REPEAT CYCLE (DAYS)	COVERAGE
MW DETECTOR	L/M	-	1	P
MW SCATTEROMETER	L	-	1	PC
LIDAR MAPPER	L/M	-	1/15/90	C
(LIDAR SPECTROMETER	L/M	-	?	?)
LIDAR SOUNDER	L	-	0.5/1	CS
LASER ALTIMETER	L	-	1/30	PS
(LASER SCATTEROMETER	L	-	?	?)
(LASER SOUNDER	L	-	?	?)
RADAR MAPPER	L	-	1/5	C
RADAR ALTIMETER	L	-	1	PC
(MH_3 RADAR SOUNDER	L	-	?	?)
SYNTHETIC APERTURE RADAR	L/M		30/4	SC
(DATA COLLECTION PLATFORM	L/M	-	?	?)

L = LOW EARTH ORBIT
M = MID EARTH ORBIT

C = COMPLETE COVERAGE
P = PARTIAL COVERAGE
S = SPOT COVERAGE

INCLINED ORBIT SENSORS

SENSOR	ALTITUDE	NODE TIME	REPEAT CYCLE (DAYS)*	COVERAGE
HI RESOLUTION SPECTRAL MAPPER	L	A/P	1	C
WIDE FIELD SPECTRAL MAPPER	L/M	A/P	1/15/30 90	C
	L/M	A & P	0.5	C
STEREO MAPPER	L/M	A/P	90/y	C
HI RESOLUTION POINTABLE MAPPER	L	-	60	P
WIDE FIELD POINTABLE MAPPER	L/M	-	15/90	P
VIS-IR VERTICAL SOUNDER	L/M	-	0.5	C
IR MAPPER	L/M	-	180	C
MM WAVE SURFACE MAPPER	L/M	-	0.5	C
MICROWAVE MAPPER	L/M	-	0.5/15	C
LOW FREQUENCY MAPPER	L	-	y	P
MICROWAVE LIMB SOUNDER	L/M	-	0.5	C
MICROWAVE VERTICAL SOUNDER	L/M	-	0.5	C
LIDAR MAPPER	L/M	-	90/y	C
(LIDAR SPECTROMETER	L/M	-	?	?)
LASER ALTIMETER	L	-	0.5/1/90	C
(LASER SCATTEROMETER	L	-	?	?)
(LASER SOUNDER	L	-	?	?)
RADAR MAPPER	L/M	-	15/y	
RADAR ALTIMETER	L	-	1	C
RADAR SOUNDER	L/M	-	0.5	C
(MH_3 RADAR SOUNDER	L	-	?	?)
SYNTHETIC APERTURE RADAR	L/M	-	y	P
(DATA COLLECTION PLATFORMS	L/M	-	?	?)

* y = Yearly

L = LOW EARTH ORBIT
M = MID EARTH ORBIT

A = A.M.
P = P.M.

C = CONTINUOUS COVERAGE
P = PARTIAL COVERAGE
S = SPOT COVERAGE

GEOGYNCHRONOUS SENSORS

SENSOR	INCLINATION	OBSERVATION TIME	REPEAT CYCLE (DAYS)**	COVERAGE
GEOS-TYPE OPTICAL SENSOR	E/I	A/P	1/15/30/60/ 90/180/y	CP
	E	A & P	0.5	C
MM WAVE MAPPER/SOUNDER	E	-	0.5	C
GEO SAR	I *	-	30/y	PSC

* SMALL INCLINATION & SMALL ECCENTRICITY

** y = YEARLY

E = EQUATORIAL
I = INCLINED

A = A.M.
P = P.M.

C = CONTINUOUS COVERAGE
P = PARTIAL COVERAGE
S = SPOT COVERAGE

DAILY REPEAT REQUIREMENTS

SENSOR	MEASUREMENT OBJECTIVE	SPATIAL/TEMPORAL REQ'TS (See p. 36)	MULTIPLE PLATFORMS
HI RES SPECT MAP	32-G OIL SPILL DETECTION	H/L/1/C	YES
	33-G RIVER & LAKE POLLUTION	H/I/1/C	YES
WIDE FIELD SPECT MAP	24-F FISH LOCATION	M/L/1/C	YES
	31-G OCEAN POLLUTION	M/L/1/C	YES
	37-H STRUCTURE DAMAGE	M/I/1/C	YES
	34-H STORM PREDICTION	L/L/0.5/C	YES*
	26-F RED TIDE	L/L/1/C	NO
STEREO MAP	25-F FISHING PATTERNS	L/L/1/C	NO
VIS-IR LIMB SOUND	28-G GAS/AEROSOLS	L/L/1/C	NO
	29-G POLLUTION TRANSPORT	L/L/1/PS	NO
	30-G POLLUTION DISTRIBUTION	L/L/1/PS	NO
	34-H STORM PREDICTION	L/L/0.5/C	YES*
VIS-IR VERT SOUND	34-H STORM PREDICTION	L/L/0.5/C	YES*

* MORNING AND AFTERNOON COVERAGE

MISSION GROUPS

Sensors are assigned to the three generic mission classes specified in the SOW for this study according to their compatibility/desirability for each class. Mission parameters such as altitude, inclination, and fleet size are matched with sensor parameters such as field of view and spatial resolution in order to meet temporal and coverage requirements listed in Table A-5.

SUN SYNCHRONOUS MISSION - LEO sun synchronous sensors, LEO polar sensors, and some LEO inclined sensors are combined on six sun synchronous platforms. (p.72)

GEOSYNCHRONOUS MISSION - All three geosynchronous compatible sensors are flown on four geosynchronous platforms. (p.73)

NON-SUN SYNCHRONOUS, NON-GEOSYNCHRONOUS MISSION - LEO inclined sensors are combined on a single platform in a 60^{o} orbit. (p.74)

SUN SYNCHRONOUS MISSION
(See p.88 for more complete definition)

ORBIT:

ALTITUDE = 955 NMI (1770 KM)

INCLINATION = 103.6^{o}

REPEAT CYCLE = 5 DAYS (59 REV)

SENSORS:

LEO SUN SYNCHRONOUS AND POLAR, SOME LEO INCLINED

WIDE FIELD OF VIEW (DAILY COVERAGE) = 78^{o}

NARROW FIELD OF VIEW (5 DAY COVERAGE) = 22^{o}

PLATFORMS:

1 PRIMARY PLATFORM FOR WIDE FIELD DAILY COVERAGE AND NARROW FIELD 5-DAY COVERAGE

4 SECONDARY PLATFORMS FOR NARROW FIELD DAILY COVERAGE

1 SUPPLEMENTAL PLATFORM FOR TWICE DAILY WIDE FIELD COVERAGE

GEOSYNCHRONOUS MISSION

(See p.89 for more complete definition)

ORBIT:

ALTITUDE = GEOSYNCHRONOUS WITH ε = .009

INCLINATION = 1°

ARGUMENT OF PERIGEE = 90°

GROUND TRACK = CIRCULAR WITH 60 NM RADIUS

SENSORS:

GEO EQUATORIAL AND INCLINED

GEOS-TYPE OPTICAL FACILITY (HI RESOLUTION, WIDE FIELD, POINTABLE)

MM WAVE MAPPER/SOUNDER (COARSE RESOLUTION, WIDE FIELD, POINTABLE)

GEOSAR (MEDIUM RESOLUTION, MEDIUM FIELD, POINTABLE)

PLATFORMS:

4 PLATFORMS LOCATED TO COVER MAJOR LAND MASSES

- 105° W FOR NORTH AMERICA, SOUTH AMERICA
- 165° E FOR AUSTRALIA, EAST ASIA
- 75° E FOR EAST AFRICA, WEST/SOUTH/CENTRAL ASIA
- 15° W FOR EUROPE, WEST AFRICA

NON-SUN-SYNCHRONOUS, NON-GEOSYNCHRONOUS MISSION
(See p.90 for more complete definition)

ORBIT:

ALTITUDE = 880 NMI (1630 KM)

INCLINATION = 60°

REPEAT CYCLE = 15 DAYS (181 REVS)

SENSORS:

LEO INCLINED

NARROW FIELD OF VIEW MICROWAVE/ACTIVE (15 DAY COVERAGE) = 10°

SPECIAL/SECONDARY SENSORS (VARIABLE COVERAGE)

PLATFORMS:

1 PLATFORM FOR HI RESOLUTION "LEISURELY" COVERAGE

VI. SENSOR COMPLEMENTS COMPATIBILITY (TASK 5)

Sensor complements are examined for operating compatibility within their mission groups. Key parameters are duty cycle, viewing, and EMI. No apparent duty cycle conflicts are uncovered, but potential viewing and EMI conflicts exist. None of these conflicts is considered unresolvable, however, and the mission groups established in Task 4 are left unaltered.

SENSOR COMPATIBILITY

<u>SUN SYNCHRONOUS MISSION</u> - Potential conflicts exist with limb sounding and off-track viewing. Solutions involve orbit selection and off-track swath matching. (p.77)

<u>GEOSYNCHRONOUS MISSION</u> - Potential conflict involves EMI that should be amenable to design solution. (p.78)

<u>NON-SUN-SYNCHRONOUS, NON-GEOSYNCHRONOUS MISSION</u> - Potential conflict with off-track viewing can be solved with swath matching. (p.79)

SUN SYNCHRONOUS MISSION SENSOR COMPATIBILITY

DUTY CYCLE: NO APPARENT CONFLICTS

- MOST PASSIVE OPTICAL SENSORS OPERATE ON VARIOUS SCHEDULES DURING DAYLIGHT PORTION OF ORBIT
- SOME IR, MW, AND ACTIVE SENSORS OPERATE DURING BOTH DAYLIGHT AND DARK PORTIONS OF ORBIT
- VIS-IR LIMB SOUNDER OPERATES DURING DARK PORTION OF ORBIT

VIEWING: POTENTIAL CONFLICTS WITH VIS-IR LIMB SOUNDER, RADAR MAPPER, AND SAR

- VIS-IR LIMB SOUNDER REQUIRES SOLAR BACK-LIGHTING
- RADAR MAPPER AND SAR LOOK OFF-TRACK
- ALL OTHER SENSORS ARE IN-TRACK LOOKING OR POINTABLE

EMI: POTENTIAL CONFLICTS DEPEND ON OPERATING FREQUENCIES

- PASSIVE MICORWAVE SENSORS ARE POSSIBLE RECEPTORS
- ACTIVE OPTICAL SENSORS ARE POSSIBLE EMITTERS
- ACTIVE MICROWAVE SENSORS ARE POSSIBLE EMITTERS AND RECEPTORS
- ALL OTHER SENSORS ARE BASICALLY NEUTRAL (EXCEPT OPTICAL SENSORS MAY RECEIVE UNWANTED ILLUMINATION)

GEOSYNCHRONOUS MISSION SENSOR COMPATIBILITY

DUTY CYCLE: NO APPARENT CONFLICTS

- GEOS FACILITY OPERATES DURING DAYLIGHT PORTION OF ORBIT AND OCCASIONALLY AT NIGHT
- MMW MAPPER/SOUNDER AND GEOSAR CAN OPERATE DAY OR NIGHT

VIEWING: NO APPARENT CONFLICTS

- ALL SENSORS POINT TO EARTH

EMI: POTENTIAL CONFLICTS DEPEND ON OPERATING FREQUENCIES

- MMW MAPPER MAY BE SENSITIVE TO SAR HARMONIES

NON-SUN-SYNCHRONOUS, NON GEOSYNCHRONOUS MISSION SENSOR COMPATIBILITY

DUTY CYCLE:	NO APPARENT CONFLICTS • MOST SENSORS CAN OPERATE DAY OR NIGHT
VIEWING:	POTENTIAL CONFLICTS WITH SAR • SAR LOOKS OFF TRACK • ALL OTHER SENSORS ARE IN-TRACK LOOKING OR POINTABLE
EMI:	POTENTIAL CONFLICTS DEPEND ON OPERATING FREQUENCIES • PASSIVE MICROWAVE SENSORS ARE POSSIBLE RECEPTORS • ACTIVE OPTICAL SENSORS ARE POSSIBLE EMITTERS • ACTIVE MICROWAVE SENSORS ARE POSSIBLE EMITTERS AND RECEPTORS • ALL OTHER SENSORS ARE BASICALLY NEUTRAL

VII. MISSION DEFINITION (TASK 6)

Mission groups are examined for mission feasibility in the 1990-2000 time frame. Key areas of concern are physical and functional accommodation of sensor complements on common platforms and installation, maintenance, and on-orbit operations. No patently unrealistic mission requirements appear to exist, although the mission groups present a number of challenges. Pointing and stability of large sensors on common platforms require advances in attitude control and platform form/figure control, particularly for geosynchronous observations. High power and data handling capabilities are required. Laser/lidar radiation hazards must be controlled. The STS must be upgraded to achieve higher LEO altitudes and sun-synchronous inclinations. An orbit transfer vehicle (OTV) is needed for geosynchronous operations and some LEO work. All of these advances are technically achievable by the 1990s, given the national will to continue with a reasonably effective space program.

Mission specifications have been generated for the three generic mission classes. They are included as Appendix B of this report.

MISSION FEASIBILITY

SUN SYNCHRONOUS MISSION - Pointing and stability, power and data, laser/lidar radiation, and transportation to high sun synchronous LEO are mission feasibility concerns. All appear achievable in the 1990-2000 time frame. (p.83)

GEOSYNCHRONOUS MISSION - Fine pointing and stability, power and data, and transportation to GEO are mission feasibility concerns. The greatest challenge is pointing and stability for high resolution ground coverage. (p.84)

NON-SUN-SYNCHRONOUS, NON-GEOSYNCHRONOUS MISSION - Pointing, power and data, laser/lidar radiation, and transportation to high LEO are mission feasibility concerns. All appear achievable in the 1990-2000 time frame. (p.85)

SUN SYNCHRONOUS MISSION FEASIBILITY

PHYSICAL ACCOMODATION

- RADAR MAPPER, SAR, MHz RADAR SOUNDER AND LIDAR MAPPER ARE MEDIUM TO LARGE; ALL OTHER SENSORS ARE SMALL OR MEDIUM SIZE
- SAR MAY REQUIRE BOTH LEFT AND RIGHT VIEWING ANTENNAS
- ALL SENSORS ARE FIXED POINTING EXCEPT IR POINTABLE DETECTOR

FUNCTIONAL ACCOMODATION

- LASER, LIDAR, AND RADAR SENSORS ARE HIGH POWER USERS
- SPECTRAL MAPPERS, STERO MAPPERS, RADAR MAPPER, AND SAR ARE HIGH DATA PRODUCERS
- RADAR AND LASER ALTIMETERS HAVE STRINGENT STABILITY REQUIREMENTS

OPERATIONS

- LASER AND LIDAR SENSORS PRODUCE POTENTIALLY HAZARDOUS RADIATION
- 955 NMI SUN SYNCHRONOUS ORBIT REQUIRES SUBSTANTIAL INCREASE IN SHUTTLE PERFORMANCE AND/OR DEVELOPMENT OF OTV

GEOSYNCHRONOUS MISSION FEASIBILITY

PHYSICAL ACCOMODATION

- GEOS AND MMW MAPPER/SOUNDER ARE LARGE
- GEO SAR IS MEDIUM TO LARGE
- ALL SENSORS ARE EARTH POINTABLE

FUNCTIONAL ACCOMODATION

- GEOSAR IS A HIGH POWER USER
- ALL SENSORS ARE HIGH DATA PRODUCERS
- ALL SENSORS HAVE STRINGENT POINTING/STABILITY REQUIREMENTS

OPERATIONS

- GEOSYNCHRONOUS PLATFORMS REQUIRE DEVELOPMENT OF OTV

NON-SUN-SYNCHRONOUS
NON-GEOSYNCHRONOUS MISSION FEASIBILITY

PHYSICAL ACCOMODATION

- MW MAPPER AND SAR ARE MEDIUM TO LARGE; ALL OTHER SENSORS ARE SMALL OR MEDIUM SIZE
- ALL SENSORS ARE FIXED POINTING EXCEPT POINTABLE MAPPER

FUNCTIONAL ACCOMODATION

- SAR, LIDAR, AND LASER SENSORS ARE HIGH POWER USERS
- MW MAPPER AND SAR ARE HIGH DATA PRODUCERS

OPERATIONS

- LASER AND LIDAR SENSORS PRODUCE POTENTIALLY HAZARDOUS RADIATION
- 880 NMI 60° ORBIT REQUIRES SOME INCREASE IN SHUTTLE PERFORMANCE OR DEVELOPMENT OF OTV

MISSION SPECIFICATIONS

MISSION SPECIFICATION - Overall mission requirements and individual sensor requirements are contained in each mission specification. (p.87)

SUN SYNCHRONOUS MISSION - Nineteen sensors are assigned to the sun-synchronous mission. Eleven additional sensors may be included if mission requirements are established. (p.88)

GEOSYNCHRONOUS MISSION - Three sensors are assigned to the geosynchronous mission. Three additional sensors may be included if mission requirements are established. (p.89)

NON-SUN-SYNCHRONOUS, NON-GEOSYNCHRONOUS MISSION - Nine sensors are assigned to the non-sun-synchronous, non-geosynchronous mission. Eleven additional sensors may be included if mission requirements are established. (p.90)

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MISSION SPECIFICATION

1.0 INTRODUCTION

2.0 MISSION REQUIREMENTS

- 2.1 MISSION OBJECTIVES
- 2.2 MISSION PARAMETERS
- 2.3 OPERATIONS
- 2.4 INSTALLATION
- 2.5 MAINTENANCE

3.0 SENSOR REQUIREMENTS

- 3.X (SENSOR X)
  - SENSOR DESCRIPTION
  - OPERATING PARAMETERS
  - MISSION CATEGORIES
  - MEASUREMENT OBJECTIVES
  - REPEAT INTERVALS

SUN SYNCHRONOUS MISSION

- 6 PLATFORMS AT ALT = 955 NMI, INC = 103.6°, R = 5 DAYS
- 9:00 AM AND 3:00 PM ORBITS
- 19 ASSIGNED SENSORS

SENSOR	PRIMARY PLATFORM	SECONDARY PLATFORM	SUPPLEMENTAL PLATFORM
SPECTRAL MAPPER	X	X	X
STEREO MAPPER	X		
RADAR MAPPER	X		
SYNTHETIC APERTURE RADAR	X		
IR MAPPER	X		X
MM WAVE SURFACE MAPPER	X		X
LIDAR MAPPER	X		
RADAR ALTIMETER	X	X	
LASER ALTIMETER	X	X	
MICROWAVE SCATTEROMETER	X	X	
VIS-IR LIMB SOUNDER	X		X
VIS-IR VERTICAL SOUNDER	X		X
MICROWAVE LIMB SOUNDER	X		X
MICROWAVE VERTICAL SOUNDER	X		X
LIDAR SOUNDER	X	X	
IR SOUNDER	X		
RADAR SOUNDER	X		X
IR DETECTOR	X		
IR POINTABLE DETECTOR	X		

- 11 ADDITIONAL SENSORS WITH UNDEFINED MISSION REQUIREMENTS:

UV MAPPER
LIDAR SPECTROMETER
LASER SCATTEROMETER
LASER SOUNDER

UV LIMB SOUNDER
MHz RADAR SOUNDER
X-RAY DETECTOR
γ-RAY DETECTOR

DCP INTERROGATOR
EUV DETECTOR
FIELD/PLASMA SENSORS

GEOSYNCHRONOUS MISSION

- 4 PLATFORMS AT GEO WITH INC = 1°, ECC = .009, ARG OF PERIGEE = 90°
- CENTERED AT 105°W, 165°E, 75°E, 15°W
- 3 ASSIGNED SENSORS:
  - GEOSYNCHRONOUS EARTH OBSERVATION SYSTEM (GEOS)
  - MILLIMETER WAVE MAPPER
  - GEOSYNCHRONOUS SYNTHETIC APERTURE RADAR (GEOSAR)
- 3 ADDITIONAL SENSORS WITH UNDEFINED MISSION REQUIREMENTS:
  - X-RAY DETECTOR
  - GAMMA RAY DETECTOR
  - EUV DETECTOR

NON SUN SYNCHRONOUS, NON-GEOSYNCHRONOUS MISSION

- 1 PLATFORM AT ALT = 880 NMI, INC = 60^{o}, R = 15 DAYS
- VARIABLE LIGHTING CONDITIONS
- 9 ASSIGNED SENSORS

MICROWAVE MAPPER	SYNTHETIC APERTURE RADAR
LOW FREQUENCY MAPPER	SPECTRAL MAPPER
LIDAR MAPPER	STEREO MAPPER
RADAR MAPPER	POINTABLE MAPPER
	LASER ALTIMETER

- 11 ADDITIONAL SENSORS WITH UNDEFINED MISSION REQUIREMENTS:

UV MAPPER	UV LIMB SOUNDER	DCP INTERROGATOR
LIDAR SPECTROMETER	MHz RADAR SOUNDER	EUV DETECTOR
LASER SCATTEROMETER	X-RAY DETECTOR	FIELD/PLASMA SENSORS
LASER SOUNDER	γ-RAY DETECTOR	

VIII. CONCLUSIONS AND RECOMMENDATIONS

The Generic Mission Specification Study has developed a unique methodology for relating mission requirements to sensor capabilities through consideration of key spectral and spatial parameters. This methodology can be extended to additional parameters and can be adapted to various levels of data definition. At the coarse screen level addressed in this study, significant understanding of future sensor requirements is obtained.

The study has defined three generic missions that satisfy a broad range of earth resources and environmental measurement objectives. While no attempt has been made to optimize parameters such as altitude, inclination, repeat cycle, field of view, and fleet size, the generic missions present reasonable solutions to mission requirements. The three missions appear feasible for the 1990-2000 time frame.

The study was performed under severe resource limitations, with the inevitable result that data developed in the study are in places incomplete and inconsistent. We recommend that additional resources be made available so that the data can be reiterated and upgraded.

Two alternate missions were considered and dropped: a GEO mission with a 30^{o} inclination, matched to seasonal lighting variations, that provides polar coverage and precludes the orbit eccentricity required for GEOSAR; and a MEO mission with a 60^{o} inclination that performs most non-sun-synchronous, non-geosynchronous mission functions plus some sun synchronous mission functions. We recommend that additional resources be made available to consider these and other mission alternatives.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS AND RECOMMENDATIONS - The study has provided a first cut at defining earth resources and environmental missions for the 1990-2000 time frame. Additional resources are needed to refine study results and extend its applicability. (p.93)

PREFERRED MISSION - The sun synchronous mission appears to offer the best baseline for DAP systems definition. (p.94)

GENERAL ELECTRIC

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CONCLUSIONS AND RECOMMENDATIONS

- THE STUDY HAS DEVELOPED A UNIQUE METHODOLOGY FOR RELATING MISSION REQUIREMENTS TO SENSOR CAPABILITIES
- THE STUDY HAS DEFINED THREE GENERIC MISSIONS THAT SATISFY A BROAD RANGE OF EARTH RESOURCES AND ENVIRONMENTAL OBJECTIVES. THE MISSIONS ARE FEASIBLE AND (IT IS HOPED) REASONABLE
- THE STUDY WAS PERFORMED UNDER SEVERE RESOURCE LIMITATIONS WITH THE INEVITABLE RESULT THAT DATA DEVELOPED ARE INCOMPLETE AND INCONSISTENT. FURTHER ITERATIONS ARE RECOMMENDED
- TWO ALTERNATE MISSIONS WERE CONSIDERED AND DROPPED: GEO AT 30° INCLINATION AND MEO AT 60° INCLINATION. FURTHER CONSIDERATION OF MISSION ALTERNATIVES IS RECOMMENDED

PREFERRED MISSION

FOR THE PURPOSE OF DAP SYSTEMS DEFINITION, THE SUN SYNCHRONOUS MISSION APPEARS TO PROVIDE THE MOST ATTRACTIVE BASELINE

- A FULL COMPLEMENT OF OPTICAL AND MICROWAVE SENSORS IS INCLUDED
  - RETINEX THEORY ANALOGY SUPPORTS FULL SPECTRAL COVERAGE
  - LARGE AND VARIED SENSOR COMPLEMENT PROVIDES PLATFORM DESIGN CHALLENGES
- SUN SYNCHRONOUS ORBIT IS A NATURAL SOLUTION FOR EARTH OBSERVATION
  - CONSTANT SUN ANGLE IS GENERALLY BEST FOR PASSIVE OPTICAL SENSING
  - REGULAR COVERAGE SCHEDULES FACILITATE OPERATIONAL SUPPORT
- MULTIPLE PLATFORMS ARE INVOLVED
  - STRINGENT TEMPORAL REQUIREMENTS ARE MET
  - DIFFERENT PLATFORM TYPES MUST BE DEFINED

IX. REFERENCES

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4. Earth Viewing Applications Laboratory Instrument Catalog, GE Space Division, 25 May 1976. (NASA Contract NAS 5-24022)

5. Shuttle Atmospheric Lidar Multi-User Instrument System, Science Objectives Experiment Descriptions Evolutionary Flow Document (SEED), LaRC (Preliminary).

6. Swathing Patterns of Earth Sensing Satellites and Their Control by Orbit Selection and Modification, GSFC; AAS No. 71-333, August 1971.

7. Nimbus 7 Reference Manual, GE Space Division, 1978.

8. Definition of the Total Earth Resources System for the Shuttle Era (TERSSE), GE Space Division, 10 Volumes, 1974, 1975. (NASA Contract NAS 9-13401)

9. The Retinex Theory of Color Vision, Edwin H. Land, Scientific American, December, 1977.

APPENDIX A

TABULAR DATA

(1) SENSOR TECHNIQUE

M = MAPPER
M_S = STEREO MAPPER

M_P = POINTABLE MAPPER

M_{SP} = POINTABLE STEREO MAPPER

D = POINT DETECTOR, NADIR LOOKING
D_P = POINT DETECTOR, POINTABLE

S = SOUNDER
S_P = POINTABLE SOUNDER
S_L = LIMB SOUNDER
S_R = SOUNDER, RANGE & RANGE RATE

ALT = ALTIMETER
SC = SCATTEROMETER

(2) SPECTRAL REGION:

UV	f = FAR	RELATES TO UV, IR
VIS	n = NEAR	
IR		
MW	m = METRIC	
	d = DECIMETRIC	
	c = CENTRIMETRIC	
	mm = MILLIMETRIC	

(3) NO. OF CHANNELS: M = MANY (> 9)
S = SEVERAL (4-9)
F = FEW (< 4)

a = ACTIVE ILLUMINATION
p = PASSIVE ILLUMINATION

(4) SPECTRAL RESOLUTION (b/u): WIDE = W (> 30 nm) (VIS-IR)
NARROW = N (< 30 nm)
- = NOT SIGNIFICANT OR RELEVANT

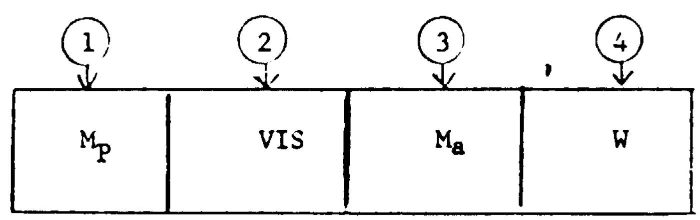

TABLE A-1. SPECTRAL MEASUREMENT REQUIREMENTS

KNOWLEDGE REQUIREMENTS \ STUDY DISCIPLINES	A AGRICULTURE	B RANGE MANAGEMENT	C FORESTRY	D GEOLOGIC RESOURCES	E LAND USE
1. VEGETATION IDENTIFICATION	M/VIS,IR/S/N	M/VIS,IR/S/N	M/VIS,IR/S/N	M/VIS,IR/S/N	M/VIS,IR/S/N
2. VEGETATION AREAL EXTENT & DISTRIBUTION (MAPS)	M/VIS,IR/S/N	M/VIS,IR/S/N	M/VIS,IR/S/N		M/VIS,IR/S/N
3. PLANT DENSITY	M_P/MW_D/F/-	M_P/MW_D/F/-	M_P/MW_C/F/-		
4. PLANT SIZE OR STAGE OF DEVELOPMENT	M_P/VIS,IR/S/N	M_P/VIS,IR/S/N	M_P/VIS,IR/S/N		
5. PLANT VIGOR	↓	↓	↓		
6. PLANT RATE OF GROWTH	↓	↓	↓		
7. PLANT STRESS, DAMAGE & THEIR SOURCE	M/VIS,IR/S/N	M/VIS,IR/S/N	M_P/VIS,IR/S/N		
8. SOIL MOISTURE VS. DEPTH	M/MW_D/S/-	M/MW_D/S/-	M/MW_D/S/N		
9. METHOD OF CULTIVATION (e.g., IRRIGATION)	M/MW_D/F/-				M/MW_D/F/-
10. GRAZING INTENSITY		M_P/VIS,IR/S/W			
11. STANDING TIMBER PER SQUARE AREA			M/MW_C/F/-		M/MW_C/F/-
12. SURFACE TEXTURE & SLOPE				SC/MW_C/S/-	
13. SOIL DENSITY, POROSITY				SC/MW_C/S/-	
14. SOIL CHEMICAL COMPOSITION - SURFACE	M/VIS,IR/S/N	M/VIS,IR/S/N	M/VIS,IR/S/N	M/VIS,IR/S/N	
15. SOIL CHEMICAL COMPOSITION VS. DEPTH	M/MW_D/M/-	M/MW_D/M/-	M/MW_D/M/-	M/VIS,IR/S/N	
16. GEOTHERMAL SOURCES				M/IR/F/-	M/IR/F/-
17. FRESH WATER RESOURCES AREA & DEPTH DISTRIBUTION					
18. SNOW COVER					
19. LOCATION & DISTRIBUTION OF BUILDING STRUCTURES					M/VIS/F/W
20. LOCATION & DISTRIBUTION OF ROADS & RAILWAYS					M/VIS/F/W
21. LAND TOPOGRAPHY	M_S/VIS/F/W	M_S/VIS/F/W			ALT/VIS/F/-
22. WATER - BODY CHEMICAL CONTENTS					
23. PLANKTON DISTRIBUTION IN OCEAN					
24. FISH LOCATION & DISTRIBUTION					
25. FISHING PATTERNS					
26. RED TIDES					
27. ICE FORMATIONS LOCATION & AREAL/VOLUMETRIC SIZE					

TABLE A-1. SPECTRAL MEASUREMENT REQUIREMENTS

KNOWLEDGE REQUIREMENTS \ STUDY DISCIPLINES	F WATER RES. & OCEAN	G ENVIRONMENTAL QUALITY	H DISASTER PRED. ASSESSMENT	I WEATHER & CLIMATE	J ATMOSPHERE	K EARTH & OCEAN DYNAMICS
1. VEGETATION IDENTIFICATION						
2. VEGETATION AREAL EXTENT & DISTRIBUTION (MAPS)						
3. PLANT DENSITY						
4. PLANT SIZE OR STAGE OF DEVELOPMENT						
5. PLANT VIGOR						
6. PLANT RATE OF GROWTH						
7. PLANT STRESS, DAMAGE & THEIR SOURCE						
8. SOIL MOISTURE VS. DEPTH						
9. METHOD OF CULTIVATION (e.g., IRRIGATION)						
10. GRAZING INTENSITY						
11. STANDING TIMBER PER SQUARE AREA						
12. SURFACE TEXTURE & SLOPE						
13. SOIL DENSITY, POROSITY						
14. SOIL CHEMICAL COMPOSITION - SURFACE						
15. SOIL CHEMICAL COMPOSITION VS. DEPTH						
16. GEOTHERMAL SOURCES						
17. FRESH WATER RESOURCES AREA & DEPTH DISTRIBUTION	M/IR/F/W					
18. SNOW COVER	M/IR/MW_C/F/W					
19. LOCATION & DISTRIBUTION OF BUILDING STRUCTURES						
20. LOCATION & DISTRIBUTION OF ROADS & RAILWAYS						
21. LAND TOPOGRAPHY						
22. WATER - BODY CHEMICAL CONTENTS	M/VIS,IR/M/N	M/VIS,IR/M/N				
23. PLANKTON DISTRIBUTION IN OCEAN	M/VIS,IR/M/N					
24. FISH LOCATION & DISTRIBUTION	M/VIS,IR/M/N					
25. FISHING PATTERNS	M/VIS/F/W					
26. RED TIDES	M/VIS/S/W					
27. ICE FORMATIONS LOCATION & AREAL/VOLUMETRIC SIZE	M/MW_{MM}/S/-		M/MW_{MM}/S/-			

TABLE A-1. SPECTRAL MEASUREMENT REQUIREMENTS

KNOWLEDGE REQUIREMENTS / STUDY DISCIPLINES	A AGRICULTURE	B RANGE MANAGEMENT	C FORESTRY	D GEOLOGIC RESOURCES	E LAND USE
28. GLOBAL DISTRIBUTION OF TROPOSPHERIC GASES/AEROSOLS					
29. POLLUTANT TRANSPORT MECHANISMS IN ATMOSPHERE					
30. AIR POLLUTANT DISTRIBUTION IN ATMOSPHERE					
31. OCEAN POLLUTION CONCENTRATIONS & DISTRIBUTION					
32. OIL SPILL DETECTION & AREAL EXTENT					
33. POLLUTION DETECTION IN RIVERS & LAKES					
34. DISASTER PREDICTION - STORMS, FLOODS					
35. DISASTER PREDICTION - TIDAL WAVES					
36. DISASTER PREDICTION/ASSESSMENT - EARTHQUAKES					
37. DISASTER DAMAGE TO STRUCTURES & FLORA					
38. ATMOSPHERE TEMPERATURE VERTICAL PROFILE					
39. CLOUD TEMPERATURE & LATENT HEAT					
40. WATER SURFACE TEMPERATURE DISTRIBUTION					
41. ATMOSPHERIC PRESSURE VERTICAL PROFILE					
42. RATE OF EVAPORATION (SPATIAL DISTRIBUTION)					
43. EARTH RADIATION DISTRIBUTION					
44. SOLAR CONSTANT					
45. WIND PROFILE & DIRECTION					
46. SEA SURFACE WIND VELOCITY & DIRECTION					
47. WAVE CHARACTERISTICS					
48. OCEAN CURRENT VELOCITY, RATE, AND COURSE					
49. COASTAL ESTUARY CIRCULATION					
50. COASTAL SHORELINE SHIFTS					
51. EARTH CRUSTAL FAULTS					
52. TECTONIC MOVEMENT					
53. LITHOLOGICAL FEATURES OF EARTH				M/IR,VIS/S/W	
54. GEOLOGICAL STRUCTURE				$M/MW_C/S/I$	
55. GEO-MORPHOLOGICAL FEATURES				M/VIS,IR/S/I	

TABLE A-1. SPECTRAL MEASUREMENT REQUIREMENTS

KNOWLEDGE REQUIREMENTS \ STUDY DISCIPLINES	F WATER RES. & OCEAN	G ENVIRONMENTAL QUALITY	H DISASTER PRED. & ASSESSMENT	I WEATHER & CLIMATE	J ATMOSPHERE	K EARTH & OCEAN DYNAMICS
28. GLOBAL DISTRIBUTION OF TROPOSPHERIC GASES/AEROSOLS		S,S_L/VIS,IR/F/N				
29. POLLUTANT TRANSPORT MECHANISMS IN ATMOSPHERE						
30. AIR POLLUTANT DISTRIBUTION IN ATMOSPHERE						
31. OCEAN POLLUTION CONCENTRATIONS & DISTRIBUTION	$M/MW_C^A/S/-$	M/VIS,IR/M/N				
32. OIL SPILL DETECTION & AREAL EXTENT	$M/MW_C^A/S/-$					
33. POLLUTION DETECTION IN RIVERS & LAKES						
34. DISASTER PREDICTION - STORMS, FLOODS			$M,S/VIS,IR,MW_{MM}/M/N$			
35. DISASTER PREDICTION - TIDAL WAVES			$ALT/VIS^A/F/N$			
36. DISASTER PREDICTION/ASSESSMENT - EARTHQUAKES			$S_R/VIS,MW_{MM}/F/-$			
37. DISASTER DAMAGE TO STRUCTURES & FLORA			M/VIS,IR/M/N			
38. ATMOSPHERE TEMPERATURE VERTICAL PROFILE			S/IR/S/N	S/IR/S/N	S/IR/S/N	
39. CLOUD TEMPERATURE & LATENT HEAT			M/IR/S/N	M/IR/S/N	M/IR/S/N	
40. WATER SURFACE TEMPERATURE DISTRIBUTION			M/IR/S/N	M/IR/S/N		
41. ATMOSPHERIC PRESSURE VERTICAL PROFILE			$S/VIS,IR^A/S/N$	$S/VIS,IR^A/S/N$	$S/VIS^A,IR^A/S/N$	
42. RATE OF EVAPORATION (SPATIAL DISTRIBUTION)			S/IR/S/N	S/IR/S/N		
43. EARTH RADIATION DISTRIBUTION			M/IR/F/W	M/IR/F/W		
44. SOLAR CONSTANT			$D_P/IR/F/W$	$D_P/IR/F/W$		
45. WIND PROFILE & DIRECTION		D/I MW/F/W	D/IR,MW/F/N	D/IR,MW/F/N	D/IR,MW/F/N	
46. SEA SURFACE WIND VELOCITY & DIRECTION						$SC/MW_C/F/-$
47. WAVE CHARACTERISTICS						$ALT/VIS,MW_C/F/-$
48. OCEAN CURRENT VELOCITY, RATE, AND COURSE		M/VIS,IR/F/W				M/VIS,IR/F/W
49. COASTAL ESTUARY CIRCULATION						
50. COASTAL SHORELINE SHIFTS						
51. EARTH CRUSTAL FAULTS						M/MW/F/-
52. TECTONIC MOVEMENT						$S_R/VIS,IR/F/-$
53. LITHOLOGICAL FEATURES OF EARTH						
54. GEOLOGICAL STRUCTURE						
55. GEO-MORPHOLOGICAL FEATURES						

SPATIAL/TEMPORAL MEASUREMENT PARAMETERS

	CATEGORY	DESCRIPTION
1	SPATIAL RESOLUTION	H. HIGH: $<$ 10 METERS M. MEDIUM: 10 - 100 METERS L. LOW: $>$ 100
2	GROUND COVERAGE PER ORBIT (e.g., SWATH WIDTH)	L. LARGE: $>$ 1000 km I. INTERMEDIATE: 200 - 1000 km S. SMALL: $<$ 200 km
3	REPEAT CYCLE	EVERY N DAYS O. ONCE Y. YEARLY
4	TYPE OF SAMPLING	C. CONTINUOUS P. PERIODIC P_S PERIODIC SPOT P_A PERIODIC AREA

EXAMPLE:

1	2	3	4
M	L	18	P_S

TABLE A-2. SPATIAL/TEMPORAL MEASUREMENT REQUIREMENTS

KNOWLEDGE REQUIREMENTS / STUDY DISCIPLINES	A AGRICULTURE	B RANGE MANAGEMENT	C FORESTRY	D GEOLOGIC RESOURCES	E LAND USE
1. VEGETATION IDENTIFICATION	M/L/9/C	M/L/9/C	M/L/80/C	M/I/O/C	M/L/90/C
2. VEGETATION AREAL EXTENT & DISTRIBUTION (MAPS)	M/L/9/C	M/L/9/C	M/L/80/C		M/L/90/C
3. PLANT DENSITY	M/I/15/Pa	M/I/15/Pa	M/L/Y/C		
4. PLANT SIZE OR STAGE OF DEVELOPMENT			M/L/Y/C		
5. PLANT VIGOR			M/I/Y/Pa		
6. PLANT RATE OF GROWTH			M/I/90/Pa		
7. PLANT STRESS, DAMAGE & THEIR SOURCE	M/L/15/C	M/L/15/C	M/I/90/Pa		
8. SOIL MOISTURE VS. DEPTH	M/L/15/C	L/L/15/C	L/L/30/C		
9. METHOD OF CULTIVATION (e.g., IRRIGATION)	L/I/Y/Pa				L/I/Y/Pa
10. GRAZING INTENSITY		H/I/60/Pa			
11. STANDING TIMBER PER SQUARE AREA			H/I/Y/Pa		M/I/Y/Pa
12. SURFACE TEXTURE & SLOPE				M/I/O/C	
13. SOIL DENSITY, POROSITY					
14. SOIL CHEMICAL COMPOSITION - SURFACE	L/L/O/C	L/L/O/C	L/L/O/C		
15. SOIL CHEMICAL COMPOSITION VS. DEPTH	L/L/O/C	L/L/O/C	L/L/O/C	L/I/O/C	
16. GEOTHERMAL SOURCES				M/I/Y/C	M/I/Y/C
17. FRESH WATER RESOURCES AREA & DEPTH DISTRIBUTION					
18. SNOW COVER					
19. LOCATION & DISTRIBUTION OF BUILDING STRUCTURES					H/L/90/C
20. LOCATION & DISTRIBUTION OF ROADS & RAILWAYS					M/L/90/C
21. LAND TOPOGRAPHY	L/L/O/C	M/L/O/C			M/L/90/C
22. WATER - BODY CHEMICAL CONTENTS					
23. PLANKTON DISTRIBUTION IN OCEAN					
24. FISH LOCATION & DISTRIBUTION					
25. FISHING PATTERNS					
26. RED TIDES					
27. ICE FORMATIONS LOCATION & AREAL/VOLUMETRIC SIZE					

TABLE A-2. SPATIAL/TEMPORAL MEASUREMENT REQUIREMENTS

KNOWLEDGE REQUIREMENTS / STUDY DISCIPLINES	F WATER RES & OCEAN	G ENVIRONMENTAL QUALITY	H DISASTER PRED. & ASSESSMENT	I WEATHER & CLIMATE	J ATMOSPHERE	K EARTH & OCEAN DYNAMICS
1. VEGETATION IDENTIFICATION						
2. VEGETATION AREAL EXTENT & DISTRIBUTION (MAPS)						
3. PLANT DENSITY						
4. PLANT SIZE OR STAGE OF DEVELOPMENT						
5. PLANT VIGOR						
6. PLANT RATE OF GROWTH						
7. PLANT STRESS, DAMAGE & THEIR SOURCE						
8. SOIL MOISTURE VS. DEPTH						
9. METHOD OF CULTIVATION (e.g., IRRIGATION)						
10. GRAZING INTENSITY						
11. STANDING TIMBER PER SQUARE AREA						
12. SURFACE TEXTURE & SLOPE						
13. SOIL DENSITY, POROSITY						
14. SOIL CHEMICAL COMPOSITION - SURFACE						
15. SOIL CHEMICAL COMPOSITION VS. DEPTH						
16. GEOTHERMAL SOURCES						
17. FRESH WATER RESOURCES AREA & DEPTH DISTRIBUTION	L/L/30/C					
18. SNOW COVER	M/I/Y/C					
19. LOCATION & DISTRIBUTION OF BUILDING STRUCTURES			H/S/1/C			
20. LOCATION & DISTRIBUTION OF ROADS & RAILWAYS						
21. LAND TOPOGRAPHY						
22. WATER - BODY CHEMICAL CONTENTS	L/L/5/C	M/L/1/C				
23. PLANKTON DISTRIBUTION IN OCEAN	L/L/5/C					
24. FISH LOCATION & DISTRIBUTION	M/L/1/C					
25. FISHING PATTERNS	L/L/1/C					
26. RED TIDES	L/L/1/C					
27. ICE FORMATIONS LOCATION & AREAL/VOLUMETRIC SIZE	M/L/5/C		M/L/1/C			

TABLE A-2. SPATIAL/TEMPORAL MEASUREMENT REQUIREMENTS

KNOWLEDGE REQUIREMENTS / STUDY DISCIPLINES	A AGRICULTURE	B RANGE MANAGEMENT	C FORESTRY	D GEOLOGIC RESOURCES	E LAND USE	
28. GLOBAL DISTRIBUTION OF TROPOSPHERIC GASES/AEROSOLS						
29. POLLUTANT TRANSPORT MECHANISMS IN ATMOSPHERE						
30. AIR POLLUTANT DISTRIBUTION IN ATMOSPHERE						
31. OCEAN POLLUTION CONCENTRATIONS & DISTRIBUTION						
32. OIL SPILL DETECTION & AREAL EXTENT						
33. POLLUTION DETECTION IN RIVERS & LAKES						
34. DISASTER PREDICTION - STORMS, FLOODS						
35. DISASTER PREDICTION - TIDAL WAVES						
36. DISASTER PREDICTION/ASSESSMENT - EARTHQUAKES						
37. DISASTER DAMAGE TO STRUCTURES & FLORA						
38. ATMOSPHERE TEMPERATURE VERTICAL PROFILE						
39. CLOUD TEMPERATURE & LATENT HEAT						
40. WATER SURFACE TEMPERATURE DISTRIBUTION						
41. ATMOSPHERIC PRESSURE VERTICAL PROFILE						
42. RATE OF EVAPORATION (SPATIAL DISTRIBUTION)						
43. EARTH RADIATION DISTRIBUTION						
44. SOLAR CONSTANT						
45. WIND PROFILE & DIRECTION						
46. SEA SURFACE WIND VELOCITY & DIRECTION						
47. WAVE CHARACTERISTICS						
48. OCEAN CURRENT VELOCITY, RATE, AND COURSE						
49. COASTAL ESTUARY CIRCULATION						
50. COASTAL SHORELINE SHIFTS						
51. EARTH CRUSTAL FAULTS						
52. TECTONIC MOVEMENT						
53. LITHOLOGICAL FEATURES OF EARTH				H/L/90/C		
54. GEOLOGICAL STRUCTURE				M/L/180/C		
55. GEO-MORPHOLOGICAL FEATURES				M/L/90/C		

TABLE A-2. SPATIAL/TEMPORAL MEASUREMENT REQUIREMENTS

KNOWLEDGE REQUIREMENTS \ STUDY DISCIPLINES	F WATER RES. & OCEAN	G ENVIRONMENTAL QUALITY	H DISASTER PRED. & ASSESSMENT	I WEATHER & CLIMATE	J ATMOSPHERE	K EARTH & OCEAN DYNAMICS
28. GLOBAL DISTRIBUTION OF TROPOSPHERIC GASES/AEROSOLS		L/L/1/C				
29. POLLUTANT TRANSPORT MECHANISMS IN ATMOSPHERE		L/L/1/P_S			L/L/30/Pa	
30. AIR POLLUTANT DISTRIBUTION IN ATMOSPHERE		L/L/1/P_S				
31. OCEAN POLLUTION CONCENTRATIONS & DISTRIBUTION	M/L/5/C	M/L/1/C				
32. OIL SPILL DETECTION & AREAL EXTENT		H/L/1/C				
33. POLLUTION DETECTION IN RIVERS & LAKES		H/I/1/C				
34. DISASTER PREDICTION - STORMS, FLOODS			L/L/0.5/C			
35. DISASTER PREDICTION - TIDAL WAVES			M/L/0.5/C			
36. DISASTER PREDICTION/ASSESSMENT - EARTHQUAKES			H/I/1/C			
37. DISASTER DAMAGE TO STRUCTURES & FLORA			M/I/1/C			
38. ATMOSPHERE TEMPERATURE VERTICAL PROFILE			L/L/0.5/C	L/L/0.5/C	L/L/1/P_S	
39. CLOUD TEMPERATURE & LATENT HEAT			L/L/0.5/C	L/L/0.5/C	L/L/1/P_S	
40. WATER SURFACE TEMPERATURE DISTRIBUTION			M/L/0.5/C	M/L/0.5/C		
41. ATMOSPHERIC PRESSURE VERTICAL PROFILE			L/L/0.5/C	L/L/0.5/C	L/L/1/P_S	
42. RATE OF EVAPORATION (SPATIAL DISTRIBUTION)			L/L/1/C	L/L/1/C		
43. EARTH RADIATION DISTRIBUTION			L/L/1/P_S	L/L/1/P_S		
44. SOLAR CONSTANT			L/L/1/P_S	L/L/1/P_S		
45. WIND PROFILE & DIRECTION		M/L/0.5/C	M/L/0.5/C	M/L/0.5/C	M/L/1/Pa	
46. SEA SURFACE WIND VELOCITY & DIRECTION						L/I/1/Pa
47. WAVE CHARACTERISTICS						M/I/1/Pa
48. OCEAN CURRENT VELOCITY, RATE, AND COURSE		M/L/1/C		M/L/1/C		M/L/15/C
49. COASTAL ESTUARY CIRCULATION						M/L/90/C
50. COASTAL SHORELINE SHIFTS						M/I/Y/C
51. EARTH CRUSTAL FAULTS						H/I/30/P_S
52. TECTONIC MOVEMENT						H/I/30/P_S
53. LITHOLOGICAL FEATURES OF EARTH						
54. GEOLOGICAL STRUCTURE						
55. GEO-MORPHOLOGICAL FEATURES						

TABLE A-3. PRELIMINARY SENSOR CONCEPTS & CHARACTERISTICS - PASSIVE

GENERIC CLASSES

Generic class	Sensor	FOV: NARROW 200 KM (LEO)	FOV: MEDIUM 200-999 KM (LEO)	FOV: WIDE 1000 KM (LEO)	FREQ BANDS: MANY (> 9)	FREQ BANDS: SEVERAL (4-9)	FREQ BANDS: 1 - 3	WIDTH OF BANDS: NARROW < 30 nm (VIS-IR)	WIDTH OF BANDS: WIDE > 30 nm (VIS-IR)	SPATIAL RESOLUTION: COARSE >100 m	SPATIAL RESOLUTION: MEDIUM 10 - 100 m	SPATIAL RESOLUTION: FINE < 10 m	POINTING: NADIR	POINTING: OFF-NADIR (INCLUDES POINTABLE)	POINTING: -LIMB	COMMENTS
GAMMA RAY DETECTOR	GAMMA RAY DETECTOR (1,2)			X			X	X			?		?			
X-RAY DETECTOR	X-RAY DETECTOR (3,4,5)			X			X	X			?		?			
UV MAPPER	UV COMP. (6)			X		X		X		X			X			
UV MAPPER	SBUV (6)			X	X			X		X			X			
UV MAPPER	ERB (7)			X	X				X	X			X	X		(WHOLE EARTH & SUN POINTED)
UV MAPPER	SSD (SOUNDER) (6)		X				X	X			X				X	
V & IR: MAPPER	SURF. FEATURE (9)		X		X			?				X	X			
V & IR: MAPPER	SURF. COMP. (10)			X	X			?			X		X			
V & IR: MAPPER	THERMAL/CLOUD (11)			X		X		?		X			X			
V & IR: MAPPER	RADIATION BUDGET (7)			X	X			?		X			X			
V & IR: MAPPER	VISIBLE GLITTER (7)		X		X			X			X		X			
V & IR: MAPPER	CFPA (12)	X				?		?				X	X			G GEOSTATIONARY CONCEPTS
V & IR: MAPPER	LANDSAT-H (9)		X		X			?				X	X			LOOKS FORE & AFT
V & IR: MAPPER	CZCS (10,11)			X		X		X		X			X			
V & IR: MAPPER	ERB (7,8)			X	X				X	X			X			
V & IR: MAPPER	TM (9)		X			X		X			X		X			
V & IR: MAPPER	RBV (7)		X				X	X			X		X			
V & IR: MAPPER	TH INERTIA MPPR (15)		X				X	?				X	X			
V & IR: MAPPER	HETERODYNE INTERFER. (14)			X	X			X		X			X			
V & IR: STEREO MAPPER	STEREO MAPPER (16)		X				X	?				X	X			
V & IR: POINTABLE MAPPER	POINTABLE IMAGER (17)		X		X			?		X				X		G
V & IR: POINTABLE MAPPER	CFPA (12)	X				?		?				X		X		
V & IR: POINTABLE MAPPER	LANDSAT-H (HRPI) (17)	X				X		?				X		X		
V & IR: POINTABLE MAPPER	AASIR (17)			X	X			X		X						G
V & IR: SOUNDER	LIMB SOUNDER (18)		X		X			X				X			X	
V & IR: SOUNDER	IR ATMOSPHERIC (19)			X	X			X				X	X			
V & IR: SOUNDER	LIMS (18)		X			X		X				X			X	
V & IR: SOUNDER	SAMS (19)		X			X		X	X		X				X	
V & IR: SOUNDER	AASIR (17)			X	X			X			?			X		POINTABLE (WHOLE EARTH COVERAGE); G
V & IR: SOUNDER	THIR (11)			X			X	X			?		X			
V & IR: SOUNDER	SAM II (17)		X				X	X		X					X	(SUN AT RISE & SET)
MICROWAVE MAPPER	MI WAVE SURF MPPR (20)			X	X			?			X		X			
MICROWAVE MAPPER	SURF MAPPER (21,23)			X	X			?		X			X			
MICROWAVE MAPPER	SWEPT FREQ SURF MPPR (22)			X		X		?		X			X			
MICROWAVE MAPPER	LOW FREQ MPPR (25)			X			X	?		X			X			
MICROWAVE MAPPER	SMMR (22,23,25)		X			X			X	X				X		
MICROWAVE MAPPER	SSM/I (21)			X			X	X		X			X			
MICROWAVE MAPPER	MICROSAT (24)		X				X	X			X		X			
MICROWAVE SOUNDER	MCM ATMOS (28)			X		X		X			X		X			
MICROWAVE SOUNDER	ATMOS SOUNDER (26)			X		X		X			X		X			
MICROWAVE SOUNDER	LIMB SOUNDER (27)			X	X			X			?				X	
MICROWAVE SOUNDER	MASR (26)			X	X			X			X			X		POINTABLE (WHOLE EARTH COVERAGE); G
MICROWAVE SOUNDER	MSU (26,28)			X		X		X			X		X			
MICROWAVE SOUNDER	SMMR (26)		X				X	X		X				X		

CFPA = CID FOCAL PLANE ARRAY (PLACE GEOS)

NUMBERS FOLLOWING SENSOR NAMES CORRESPOND TO SENSORS ON P43

TABLE A-4. PRELIMINARY SENSOR CONCEPTS & CHARACTERISTICS - ACTIVE

GENERIC CLASSES	UV, VISIBLE & IR: LASER RADAR (LIDAR)									UV, VISIBLE & IR: LASER ALTIMETER	UV, VISIBLE & IR: LASER SCATTEROMETER			MICROWAVE & RF: REAL APERTURE RADAR									MICROWAVE & RF: SYNTHETIC APERTURE RADAR			
	SURFACE COMP. (31)	OCEAN THERMAL (39)	PRESSURE #1 (38)	PRESSURE #2 (38)	DOPPLER (37)	PULSED ATMOSPHERIC (37)	CW ATMOSPHERIC (38)	LANDSAT-H NITE-LITE (32)	TEMPERATURE SOUNDING (39)	LASER ALTIMETER (33)	LASER SCATTEROMETER (34)	LANDSAT-H LUMINESCENCE DETECTOR (35)	TRACE SPECIES BY OCCULTATION (2 PLATFORMS) (36)	SCATTEROMETER RADAR (41,44)	RADAR (CHIRP) ALTIMETER (42)	DOPPLER RADAR (40)	PRESSURE RADAR (40)	MHz RADAR (40)	RAIN RADAR (40)	BISTATIC RADAR (40)	SWEPT FREQ. RADAR (40,43)	WAVE SPECTRA RADAR (40)	SAR (45)	SWEPT FREQ. SAR (46)	LANDSAT-H SAR (45)	GEOSAR (42)
FOV:																										
NARROW < 200 km	X	X		X		X				X			X		X		X									
MEDIUM 200-1000 km			X		X		X	X	X		X	X						X		X				X	X	
WIDE > 1000 km (LEO)														X		X			X		X	X	X			X
FREQUENCY BANDS:																										
MANY (> 9)	X					X	X						X											X		
SEVERAL (4-9)			X	X											X		X		X		X		X			
1 - 3		X			X			X	X	X	X	X		X		X		X		X		X			X	X
WIDTH OF BANDS:																										
NARROW < 30 nm	X	X	X		X	X	X	X (2 MODES)	X	?	?	?	X	X	X	X	X	X	X	X	X		X	X	?	X
WIDE > 30 nm (VIS-IR)				X				X (2 MODES)														X				
SPATIAL RESOLUTION:																										
COARSE > 100 m		X			X	X	X		X		X			X		X	X		X	X	X					
MEDIUM 10-100 m	X		X									?						X							X	X
FINE < 10 m				X				X		X			X		X								X	X		
POINTING:																										
NADIR	X	X	X	X	X	X	X		X	X	X				X		X	X		X						
FIXED } OFF-NADIR								X				X		X		X			X		X	X	X	X	X	X
POINTABLE } OFF-NADIR																										
LIMB													X (POINTS AT 2ND SATELLITE)													

NUMBERS FOLLOWING SENSOR NAMES CORRESPOND TO SENSORS ON P44

REQUIREMENTS MATRIX

1. Spectral Performance (Spectral Perf)

Regime:
- γ = γ-Ray
- X = X-Ray
- UV = Ultraviolet
- VIS = Visible Light
- IR = Infrared
- MW_H = High Frequency Microwave
- MW_L = Low Frequency Microwave

Channels (CH):
- M = Many (>9)
- S = Some (4-9)
- F = Few (<4)

Band Width (BW):
- W = Wide > 30 nm (VIS-IR)
- N = Narrow < 30 nm

2. Spatial Performance (Spatial Perf)

Pointing (PT):
- N = Nadir
- O = Off-Nadir
- L = Limb
- P = Pointable

Field of View (FOV):
- W = Wide >1000 km
- M = Medium 200 - 1000 km (LEO)
- N = Narrow < 200 km

Resolution (RES):
- C = Coarse > 100 m
- M = Medium 10-100 m
- F = Fine < 10 m

3. Knowledge Requirement (Knowl Req't)

Knowledge Requirement & Mission Category from Tables A-1/A-2

4. Mission Requirements (Mission Rec'ts)

Target (TGT):
- W = Whole Earth
- T = Temperate Zone & Tropics

Repeat Cycle (RPT): Number of Days
- O = Occasionally
- Y = Yearly

Coverage (CCV):
- C = Complete
- P = Partial
- S = Spot

5. Light-Sun Angle (Light-Sun)

- D = Daylight
- D_T = Daylight at a Set Time
- D/N = Day or Night
- T = Terminator (Back-Lighted)

6. Obliquity (OBLIQ)

- OK = Can look Off-Nadir
- NO = Cannot look Off-Nadir
- REQ'D = Must look Off-Nadir
- NA = Not Applicable

7. Altitude (ALT)

- L = LEO = Low Earth Orbit
- M = MEO = Mid Earth Orbit
- G = GEO = Geosynchronous Earth Orbit

8. Inclination (INC)

- I = Inclined
- E = Equatorial
- P = Polar
- S = Sun Synchronous

9. Node Time (NODE TIME)

- A = AM = Morning
- P = PM = Afternoon
- VAR = Variable
- NA = Not Applicable

10. Precession Cycle (PREC CYCLE)

Number of Days
- S = Sun Synchronous
- VAR = Variable
- NA = Not Applicable

11. Duty Cicle (DUTY CYCLE)

Fraction of Orbit during which Sensor operates

12. Viewing (VIEW)

- N = Nadir
- O = Off-Nadir
- T = Discrete Targets
- L = Limb
- S = Scan

13. Electromagnetic Interference (EMI)

- E = Emitter
- R = Receptor
- N = Neutral

14. Shape/Size (SHAPE/SIZE)

Box, etc./Small, Medium, Large

15. Electric Power (PWR)

- N = Normal
- H = High

16. Sensor Data (DATA)

- N = Normal
- H = High

17. Thermal Control (TC)

- N = Normal
- H = High
- Cryo = Cryogenic

18. Stability (STAB)

- N = Normal
- H = High

19. Target Scanning/Tracking (SCAN/TRACK)

- S = Scan
- T = Track
- NA = Not Applicable

20. Active Illumination (ILL)

- N = Normal } { L = Laser
- H = High } { M = Microwave

21. Installation (INST)

- U = Unit } { D = Direct Ascent
- S = Subassembly } { T = Orbit Transfer

22. On-Orbit Maintenance (MAINT)

- N = Normal
- S = Special

TABLE A-5. REQUIREMENTS MATRIX

SENSOR TYPE	(1) SPECTRAL PERF REGIME	CH.	B.W.	(2) SPAT. PERF. PT.	FOV	RES	(3) KNOWL REQT	(4) MISS. REQTS TGT	RPT	COV	(5) LIGHT- SUN	(6) OBLIQ	(7) ALT	(8) INC	(9) NODE TIME	(10) PREC CYCLE	(11) DUTY CYCLE	(12) VIEW	(13) EMI	(14) SHAPE/SIZE	(15) PWR	(16) DATA	(17) T.C.	(18) STAB	(19) SCAN/ TRACK	(20) ILL.	(21) INST.	(22) MAINT.
(PASSIVE)																												
γ-RAY DETECTOR	γ	S	W	N/L	W/M/N	C	-	-	-	-	D/N	OK	(L/M)	(P/I)	(NA)	(NA)	-	N/L(O)	N									
													(G)	(E)														
X-RAY DETECTOR	X	S	W	N/L	W/M/N	C	-	-	-	-	D/N	OK	(L/M)	(P/I)	(NA)	(NA)	-	N/L(O)	N									
													(G)	(E)														
EUV DETECTOR	UV	S	W	N/L	W/M/N	C	-	-	-	-	D/N	OK	(L/M)	(P/I)	(NA)	(NA)	-	N/L(O)	N									
													(G)	(E)														
UV MAPPER	UV	M	W/N	N	W	C	-	-	-	-	D	OK	(L/M)	(P/I)	(VAR)	(VAR)	-	N (O)	N									
UV SOUNDER	UV	F	N	L	M	M	-	-	-	-	T	NA	(L/M)	(P/I)	(VAR)	(VAR)	-	L	N									
HI RES SPECTRAL MAPPER	VIS-IR	M	W/N	N	M	F	33-G	T	1	C	D_T	OK	L	S	AP	S	1/2	N(O)	N	BOX/SMALL	N	H	CRYO?	N	NA	NA	U/D	N
													(G)	(E)	(NA)	(NA)	(VAR)	(S)		(CYL/LRGE)								
WIDE FIELD SPECTRAL MPPR	VIS-IR	M/S	W/N	N	W/M	C/M	1 D	W	0	C	D_T	OK	L/M	S	AP	S	1/8	N(O)	N	BOX/SMALL	N	H	CRYO?	N	NA	NA	U/D	N
							15-D																					
							22-F	W	5	C			L/M	S	AP	S	1/2	N(O)										
							23-F																					
							24-F	W	1	C			L/M	S	AP	S	3/8	N(O)										
							31-G																					
							26-F																					
							14-ABC	T	0	C			L/M	S(I)	AP	S(NA)	1/8	N(O)										
							1-C	T	Y	C			L/M	S(I)	AP	S(NA)	1/8	N(O)										
							2-C																					
							1-AB	T	90	C			L/M	S(I)	AP	S(90)	1/8	N(O)										
							2-AB																					
							7-C	T	90	P			L/M	S(I)	AP	S(90)	1/10	N(O)										
							8-C	T	30	C			L/M	S(I)	AP	S(30)	1/10	N(O)										
							7-AB	T	15	C			L/M	S(I)	AP	S(15)	1/8	N(O)										
							37-H	T	1	C			L/M	S(I)	AP	S(1)	1/10	N(O)										
							34-H	T	0.5	C			L/M	S(I)	A&P	S(1)	1/2	N(O)										
							--						(G)	(E/I)	(NA)	(NA)	(VAR)	(S)		(CYL/LRGE)								
STEREO MAPPER	VIS-IR	F	W/N	N	M	M/F	49-K	W	90	C	D_T	NO	L	S	AP	S	1/10	N	N	BOX/SMALL	N	H	N	N	NA	NA	U/D	
							48-K	W	15	C			L	S	AP	S	3/8	N										
							25-F	W	1	C			L	S	AP	S	3/8	N										
							21-AB	T	0	C			L	S(I)	AP	S(NA)	1/8	N										
							50-K	T	Y	C			L	S(I)	AP	S(NA)	1/10	N										
							19-E	T	90	C			L	S(I)	AP	S(90)	1/8	N										
							20-E																					
							--						(G)	(E/I)	(NA)	(NA)	(VAR)	(S)		(CYL/LRGE)								
HI RES POINTABLE MAPPER	VIS-IR	M/S	W/N	P	N	F	10-B	T	60	P	D	OK	L	S(I)	VAR	S(60)	1/10	O/T	N	BOX/SMALL	N	N	N	N	T?	NA	U/D	N
							--						(G)	(E)	(NA)	(NA)	(VAR)	(S)		(CYL/LRGE)								
WIDE FIELD POINT. MAPPER	VIS-IR	M/S	W/N	P	W/M	C	4-C	T	Y	C	D	OK	L/M	I(S)	NA	NA	1/10	O	N	BOX/SMALL	N	N	N	N	T?	NA	U/D	N
							5-C	T	Y	P			L/M	I(S)	NA	NA	1/10	O/T	N									
							6-C	T	90	P			L/M	I(S)	NA	90	1/10	O/T										
							4-AB	T	15	P			L/M	I(S)	NA	?	1/8	O										
							5-AB	T	15	P			L/M	I(S)	NA	?	1/8	O/T										
							6-AB																					
							--						(G)	(S)	(NA)	(NA)	(VAR)	(S)		(CYL/LRGE)								

TABLE A-5. REQUIREMENTS MATRIX (cont'd)

	(1) SPECTRAL PERF			(2) SPAT. PERF.			(3) KNOWL	(4) MISS. REQTS			(5) LIGHT-	(6)	(7)	(8)	(9) NODE	(10) PREC	(11) DUTY	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19) SCAN/	(20)	(21)	(22)
SENSOR TYPE	REGIME	CH.	B.W.	PT.	FOV	RES	REQT.	TGT	RPT	COV	SUN	OBLIQ	ALT	INC	TIME	CYCLE	CYCLE	VIEW	EMI	SHAPE/SIZE	PWR	DATA	T.C.	STAB	TRACK	ILL.	INST.	MAINT.
VIS-IR LIMB SOUNDER	VIS-IR	M/S/F	W/N	L	M	M/F	28-G	W	1	C	T	NA	L/M	P	(MULTI SAT) VAR	VAR	1/10	L	N	BOX/SMALL	N	N	N	N	NA	NA	U/D	N
							29-G																					
							30-G	W	1	S			L/M	S	(MULTI SAT) VAR	S												
							34-H	T	0.5	C			L/M	P	(MULTI SAT) VAR	VAR												
VIS-IR VERTICAL SOUNDER	VIS-IR	M	N	N	W	M	34-H	T	0.5	C	D	NO	L/M	I(S)	(MULTI SAT) VAR	VAR	1/2	N	N	BOX/SMALL	N	N	N	N	NA	NA	U/D	N
IR MAPPER	IR	S/F	W/N	N	W/M	C/M/F	39-J	W	1	S	D/N	OK	L/M	P(S)	VAR	VAR	1	N(O)	N	BOX/SMALL	N	N	N	N	NA	NA	U/D	N
							43-HI																					
							39-HI	W	0.5	C			L/M	P(S)	VAR	VAR	1	N(O)										
							17-F	T	180	C			L/M	I	VAR	VAR	1/10	N(O)										
							18-F																					
IR SOUNDER	IR	M/S/F	W/N	N	W	M/F	42-HI	W	1	C	D/N	NO	L/M	P(S)	VAR	VAR	1	N	N	BOX/SMALL	N	N	N	N	NA	NA	U/D	N
							38-J	W	1	S			L/M	P(S)	VAR	VAR	1	N										
							38-HI	W	0.5	C			L/M	P(S)	VAR	VAR	1	N										
IR DETECTOR	IR	F	W/N	N	W	M	45-I	W	1	P	D/N	OK	L/M	P(S)	VAR	VAR	1	N(O)	N	BOX/SMALL	N	N	N	N	NA	NA	U/D	N
							45-GH	W	0.5	P			L/M	P(S)	VAR	VAR	1	N(O)										
IR POINTABLE DETECTOR	IR	F	W/N	P	W	C	44-HI	W	1	S	D/N	OK	L/M	P(S)	VAR	VAR	1	N(O)	N	BOX/SMALL	H	N	N	N	T	NA	U/D	N
MW SURFACE MAPPER	MW_H	M	W/N	N	W	M	34-H	T	0.5	C	D/N	OK	L/M	I	NA	NA	1/8	N(O)	R?	DISH/SMALL	N	N	N	N	NA	NA	U/D	N
													(G)	(E)	(NA)	(NA)	(VAR)	(S)										
MW MAPPER	MW_{HL}	M/S/P	W/N	N	W/M	C	15-ABC	T	0	C	D/N	OK	L/M	I	NA	NA	1/4	N(O)	R?	DISH/SMALL OR TO HORN LARGE	N	H?	N	N	NA	NA	U/D S/T	N
							8-A	T	15	C			L/M	I	NA	NA	1/4	N(O)										
LOW FREQ MAPPER	MW_L	F	W/N	N	W/M	C/M	9-A	T	Y	P	D/N	OK	L/M	I	NA	NA	1/4	N(O)	R?	DISH/LARGE	N	N	N	N	NA	NA	S/D T	N
MW LIMB SOUNDER	MW_H	M	N	L	W	M	34-H	T	0.5	C	D/N	NA	L/M	I	NA	NA	1	L	R?	DISH/SMALL	N	N	N	N	NA	NA	U/D	N
MW VERTICAL SOUNDER	MW_H	M/S/T	W/N	N	W/M	C/M	34-H	T	0.5	C	D/N	NO	L/M	I	NA	NA	1	N	R?	DISH/SMALL	N	N	N	N	NA	NA	U/D	N
MW DETECTOR	MW_H	P	N	N	W	M	45-H	W	1	P	D/N	OK	L/M	P	NA	NA	1	N(O)	R?	DISH/SMALL	N	N	N	N	NA	NA	U/D	N
							45-GI	W	0.5	C			L/M	P	NA	NA	1	N(O)										
(ACTIVE)																												
MW SCATTEROMETER	MW_H	S/F	W/N	N	M	C/M	12-D	W	0	C	D/N	NO	L/M	P	NA	NA	1/4	N	E/R?	DISH/SMALL	N	N	N	N	NA	NM	U/D	N
							13-D																					
							46-IC	W	1	P			L/M	P	NA	NA	3/4	N										
LIDAR MAPPER	VIS-IR	F	W/N	N	M	C/M/F	49-K	W	90	C	D/N	NO	L/M	P	NA	NA	1/4	N	E?	BOX/MED TO LARGE	H	N	N	N	NA	HL	U/D S/T	N
							48-K	W	15	C			L/M	P	NA	NA	3/4	N										
							25-F	W	1	C			L/M	P	NA	NA	3/4	N										
							21-AB	T	0	C			L/M	I	NA	NA	1/4	N										

TABLE A-5. REQUIREMENTS MATRIX (cont'd)

SENSOR TYPE	(1) SPECTRAL PERF REGIME	CH.	B.W.	(2) SPAT. PERF. PT.	FOV	RES	(3) KNOWL REQT.	(4) MISS. REQTS TGT	RPT	COV	(5) LIGHT-SUN	(6) OBLIQ	(7) ALT	(8) INC	(9) NODE TIME	(10) PREC CYCLE	(11) DUTY CYCLE	(12) VIEW	(13) EMI	(14) SHAPE/SIZE	(15) PWR	(16) DATA	(17) T.C.	(18) STAB	(19) SCAN/TRACK	(20) ILL.	(21) INST.	(22) MAINT.
LIDAR MAPPER (CONT'D)							50-K	T	Y	C			L/M	I	NA	NA	1/4	N										
							19-E	T	90	C			L/M	I	NA	NA	1/4	N										
							20-E																					
LIDAR SPECTROMETER	VIS-IR	M	W/N	N	N	M	-	-	-	-	D/N	NO	(L/M)	(I/P)	(NA)	(NA)	?	N	E?	BOX/MED	H	N	N	N	NA	HL	U/D S/T	N
LIDAR SOUNDER	VIS-IR	M/S/F	W/N	N	M/N	C/M/F	41-J	W	1	S	D/N	NO	L/M	P	NA	NA	1	N	E?	BOX/MED	H	N	N	N	NA	HL	U/D S/T	N
							42-HI	W	0.5	C																		
LASER ALTIMETER	VIS-IR	F	W/N	N	N	F	52-K	W	30	S	D/N	NO	L/M	P	NA	NA	1/4	N	E?	BOX/MED	H	N	N	H	NA	HL	U/D S/T	N
							47-K	W	1	F			L/M	P	NA	NA	1/2	N										
							21-E	T	90	C			L/M	I	NA	NA	1/4	N										
							36-H	T	1	C			L/M	I	NA	NA	1/4	N										
							35-H	T	0.5	C			L/M	I	NA	NA	3/4	N										
LASER SCATTEROMETER	VIS-IR	F	W/N	N	M	C	-	-	-	-	D/N	NO	(L/M)	(I/P)	(NA)	(NA)	-	N	E?	BOX/MED	H	N	N	N	NA	HL	U/D S/T	N
LASER SOUNDER	VIS-IR	M	W/N	SAT TO SAT	N	F	-	-	-	-	D/N	NA	(L/M)	(I/P)	(VAR)	(VAR)	-	SAT TO SAT	E?	BOX/MED	H	N	N	N	NA	HL	U/D S/T	N
RADAR MAPPER	MH_{HL}	M/S/F	W/N	O/N	W/M	C/M	27-F	W	5	C	D/N	REQD/ NO	L/M	P	NA	NA	3/4	O	E/R?	ANT/MED TO LARGE	H	H	N	N	NA	HM	U/D S/T	N
							31-F																					
							27-H	W	1	C			L/M	P	NA	NA	1/10	O										
							3-C	T	Y	C			L/M	I	NA	NA	1/3	O/N										
							11-CE	T	Y	P			L/M	I	NA	NA	1/8	O/N										
							3-AB	T	15	P			L/M	I	NA	NA	1/4	O/N										
							8-B																					
RADAR ALTIMETER	MW_{HL}	S	N	N	N	F	47-K	W	1	P	D/N	NO	L/M	P	NA	NA	3/4	N	E/R?	ANT/MED	H	N	N	H	NA	NM	U/D S/T	N
							36-H	T	1	C			L/M	I	NA	NA	1/4	N										
RADAR SOUNDER	MH_{HL}	S	N	O/N	W/M/N	C	34-H	T	0.5	C	D/N	REQD/ NO	L/M	I	NA	NA	1	O/N	E/R?	ANT/MED	H	N	N	N	NA	NM	U/D S/T	N
MHz RADAR SOUNDER	MW_L	F	N	N	M	M	-	-	-	-	D/N	NO	(L/M)	(I/P)	(NA)	(NA)	-	N	E/R?	ANT/LARGE	H	N	N	N	NA	NM	S/D T	N
SAR	MW_{HL}	M/S/F	W/N	O	W/M	M/F	16-D	W	0	C	D/N	REQD	L/M	P	NA	NA	1/4	O	E/R?	ANT/MED TO LARGE	H	H	N	N	NA	NM	U/D S/T	N
							51-K	W	30	S			L/M	P	NA	NA	1/4	O										
							11-CE	T	Y	P			L/M	I	NA	NA	1/8	O										
							-						(G)	(I)	(NA)	(NA)	(VAR)	(S)		(ANT/LARGE)								
DCPs (AMPA)	RF	M	N	P	N	F	-	-	-	-	D/N	OK	(L/M)	(I/P)	(NA)	(NA)	(1/10)	T	N	ARRAY/MED	N	N	N	N	NA	NA	U/D T	N
GRAVITY FIELD SENSORS	GRAV	F	W	S	W	C	-	-	-	-	D/N	NA	(L/M)	(I/P)	(NA)	(NA)	-	NA	N									
MAGNETIC FIELD SENSORS	MAG	F	W	S	W	C	-	-	-	-	D/N	NA	(L/M	(I/P)	(NA)	(NA)	-	NA	N									
PARTICLE/PLASMA SENSORS	P/P	M/S/F	W/N	S	W	C	-	-	-	-	D/N	NA	(L/M/G)	(I/P/E)	(NA)	(NA)	-	NA	N									

APPENDIX B

GENERIC MISSION SPECIFICATIONS

MISSION SPECIFICATION

Sun Synchronous Mission

1.0 INTRODUCTION

This document describes a generic sun synchronous mission that has been developed to satisfy a broad range of objectives in the earth resources and environmental discipline areas. The sensors that are assigned to this mission have been selected through an analysis of measurement requirements and have been examined for compatibility with the mission and with each other. The resulting mission emphasizes timely coverage of abrupt events and transient phenomena.

The following sensors are assigned to this mission:

Sensor	Primary Platform	Secondary Platform	Supplemental Platform
Spectral Mapper	X	X	X
Stereo Mapper	X		
Radar Mapper	X		
Synthetic Aperture Radar	X		
IR Mapper	X		
MM Wave Surface Mapper	X		X
Lidar Mapper	X		
Radar Altimeter	X	X	
Laser Altimeter	X	X	
Microwave Scatterometer	X	X	
VIS-IR Limb Sounder	X		X
VIS-IR Vertical Sounder	X		X
Microwave Limb Sounder	X		X
Microwave Vertical Sounder	X		X
Lidar Sounder	X	X	
IR Sounder	X		
Radar Sounder	X		X
IR Detector	X		
IR Pointable Detector	X		

The following sensors may be included if mission requirements are established:

UV Mapper	UV Limb Sounder	DCP Interrogator
Lidar Spectrometer	MH_z Radar Sounder	EUV Detector
Laser Scatterometer	X-ray Detector	Field/Plasma Sensors
Laser Sounder	γ-ray Detector	

2.0 MISSION REQUIREMENTS

The following requirements pertain to the mission as a whole and define the characteristics of the mission and its implementing elements.

2.1 MISSION OBJECTIVES

The generic sun synchronous mission meets requirements for frequent coverage of abrupt events and transient phenomena. Additional objectives that can benefit from the data and coverage provided are included as appropriate. The mission is designed to provide high resolution coverage on daily and 5-day cycles, and wide field coverage on a daily and twice daily basis. The mission has been assigned a relatively high altitude to minimize orbit decay for large platforms with low ballistic coefficients. Most platforms in the mission are located in a common orbit plane to facilitate deployment and servicing.

2.2 MISSION PARAMETERS

The mission uses a sun synchronous orbit at an altitude of 955 nmi (1770 km) and an inclination of 103.6^{o}. This orbit provides a 5 day repeat cycle with 59 revolutions. Complete coverage of the earth (except for the poles) is obtained every 5 days by sensors whose total field of view is 22^{o}. Complete daily coverage is obtained by sensors whose total field of view is 78^{o}.

A primary platform carries a full complement of wide field of view (78^{o}) sensors for daily coverage and narrow field of view (22^{o}) sensors for 5 day coverage. Four secondary platforms carry partial complements of narrow field (22^{o}) sensors. The secondary platforms are located in the same orbit plane as the primary platform; two of them lead the primary platform by 72^{o} and 144^{o} respectively, and two of them trail the primary platform by the same amounts. Hence the five platforms together provide complete daily coverage with narrow field of view (22^{o}) sensors.

The primary and secondary platforms are located in an orbit that provides morning coverage ($\sim$ 9:00 a.m.). A supplemental platform carrying a partial complement of wide field of view (78^{o}) sensors is located in an orbit that provides afternoon coverage ($\sim$3:00 p.m.). The primary and supplemental platforms together provide twice daily coverage.

2.3 OPERATIONS

Passive optical sensors on all platforms generally operate during the daylight portion of each orbit. Exceptions are far-IR sensors that may operate both day and night, yielding twice-daily coverage. Microwave and active optical sensors may do likewise. A VIS-IR limb sounder operates during the night portion of each orbit, looking toward the back-lighted limb of the earth.

2.4 INSTALLATION

Platforms and sensors will be installed in orbit in accordance with STS capabilities and practices existing in the 1990s. These may include direct injection, modular buildup, and orbit transfer activities. Provision should be made for sensor additions, modifications, or replacements, performed either on orbit or by means of retrieval and reflight.

2.5 MAINTENANCE

Platforms and sensors will be maintained during their operating lifetime in accordance with STS capabilities and practices existing in the 1990s. Maintenance will be accomplished either on orbit or by means of retrieval and reflight.

3.0 SENSOR REQUIREMENTS

The following requirements pertain to the individual sensors included in the mission. Sensor descriptions and operating parameters are traced to mission objectives and measurement requirements.

3.1 SPECTRAL MAPPER

A spectral mapper provides multispectral imagery in the visible-IR range. Two versions of the sensor are included in the generic sun synchronous mission: a narrow field of view (22^o) mapper that provides high resolution imagery, and a wide field of view (78^o) mapper that provides medium resolution imagery. The narrow field mapper flies on the primary and secondary platforms, providing daily coverage of the earth to within 11^o of the poles. The wide field mapper flies on the primary and supplemental platforms, providing twice-daily coverage of the earth including the poles.

HI RES SPECT MAP (22^o FOV)

MISS CAT / KNOWL REQ'T	WATER RESOURCES & OCEAN	ENVIRONMENTAL QUALITY	DISASTER PREDICTION & ASSESSMENT
Fish Location & Dist.	Daily		
Ocean Pollution		Daily	
Oil Spill Surveillance		Daily	
River/Lake Pollution		Daily	
Structure/Flow Damage			Daily

WIDE FIELD SPECT MAP (78^o FOV)

MISS CAT / KNOWL REQ'T	AGRICULTURE	RANGE MGT	FORESTRY
Vegetation Ident	90 days	90 days	Yearly
Vegetation Dist.	90 days	90 days	Yearly
Plant Stress	15 days	15 days	30 days
Soil Moisture			30 days
Soil Surface Comp.	Occasionally	Occasionally	Occasionally

MISS CAT / KNOWL REQ'T	GEOLOGICAL RESOURCES	WATER RESOURCES & OCEAN	DISASTER PRED. & ASSESSMENT
Vegetation Ident	Occasionally		
Subsoil Comp	Occasionally		
Water Body Chemicals		5 days	
Plankton Distribution		5 days	
Red Tides		Daily	
Storm/Flood Prediction			Twice daily

3.2 STEREO MAPPER

A stereo mapper provides monochromatic or polychromatic overlapping imagery in the visible-IR range. Two versions of the sensor are included in the generic sun synchronous mission: a narrow field of view (22°) mapper that provides high resolution imagery, and a wide field of view (78°) mapper that provides medium resolution imagery. Both mappers fly on the primary platform, providing high resolution coverage of the earth to within 11° of the poles on a five day cycle and medium resolution coverage of the earth, including the poles, on a daily basis.

HI RES STEREO MAPPER (22° FOV)

MISS CAT / KNOWL REQ'T	RANGE MANAGEMENT	LAND USE	EARTH & OCEAN DYNAMICS
Buildings/Structures		90 days	
Roads/Railroads		90 days	
Land Topography	Occasionally		
Coastal Shoreline Shifts			Yearly

WIDE FIELD STEREO MAPPER (78° FOV)

MISS CAT / KNOWL REQ'T	AGRICULTURE	WATER RESOURCES & OCEAN	EARTH & OCEAN DYNAMICS
Land Topography	Occasionally		
Fishing Patterns		Daily	
Ocean Currents			15 days
Estuary Circulation			90 days

3.3 RADAR MAPPER

A radar mapper provides all weather imagery in the microwave range. A wide field of view (78°) fore or aft-looking antenna is flown on the primary platform, providing medium resolution coverage of the earth, including the poles, on a daily basis.

RADAR MAP (78° FOV)

MISS CAT / KNOWL REQ'T	AGRICULTURE	RANGE MANAGEMENT	FORESTRY
Plant Density	15 days	15 days	Yearly
Soil Moisture		15 days	
Standing Timber			Yearly

MISS CAT / KNOWL REQ'T	LAND USE	WATER RESOURCES & OCEAN	DISASTER PRED. & ASSESSMENT
Standing Timber	Yearly		
Ice Formations		5 days	Daily
Ocean Pollution		5 days	

3.4 SYNTHETIC APERTURE RADAR

A SAR provides all weather imaging in the microwave range. A side-looking antenna with a total field of view of 22° is flown on the primary platform, providing medium resolution coverage of the earth, including the pole on the antenna side of the platform and to within 17° of the other pole, on a 5-day cycle.

SAR (22° FOV)

KNOWL REQ'T \ MISS CAT	FORESTRY	GEOLOGICAL RESOURCES	LAND USE
Standing Timber	Yearly		Yearly
Geo. Deposits/Formations		Occasionally	

KNOWL REQ'T \ MISS CAT	EARTH & OCEAN DYNAMICS		
Earth Crustal Faults	30 days		

3.5 IR MAPPER

An IR mapper provides daylight and night imaging in the far IR range. A wide field of view (78°) mapper is flown on the primary platform, providing coarse resolution coverage of the earth, including the poles, twice each day.

IR MAP (78° FOV)

KNOWL REQ'T \ MISS CAT	WATER RESOURCES & OCEAN		
Fresh Water Res Area Dist	180 days		
Fresh Water Res Depth Dist	180 days		

KNOWL REQ'T \ MISS CAT	DISASTER PRED. & ASSESSMENT	WEATHER & CLIMATE	ATMOSPHERE
Cloud Temperature/Heat	Twice daily	Twice daily	Daily
Earth Radiation Dist	Daily	Daily	

3.6 MM WAVE SURFACE MAPPER

An MM wave surface mapper provides all weather imaging in the high frequency (Q,U, W band) microwave region. A wide field of view (78°) mapper is flown on the primary and supplemental platforms, providing medium resolution morning and afternoon coverage of the earth, including the poles, on a daily basis.

MMW SURF MAP (78° FOV)

MISS CAT / KNOWL REQ'T	DISASTER PRED. & ASSESSMENT		
Storm/Flood Prediction	Twice daily (a.m. & p.m.)		

3.7 LIDAR MAPPER

A Lidar mapper provides day and night monochromatic imaging in the visible-IR range. A wide field of view (78°) mapper is flown on the primary platform, providing medium resolution coverage of the earth, including the poles, twice each day.

LIDAR MAP (78° FOV)

MISS CAT / KNOWL REQ'T	AGRICULTURE	RANGE MGT	LAND USE
Buildings/Structures			90 days
Roads/Railroads			90 days
Land Topography	Occasionally	Occasionally	

MISS CAT / KNOWL REQ'T	WATER RESOURCES & OCEAN	EARTH & OCEAN DYNAMICS	
Fishing Patterns	Daily		
Ocean Currents		15 days	
Estuary Circulation		90 days	
Shoreline Shifts		Yearly	

3.8 RADAR ALTIMETER

A radar altimeter provides all weather ranging data in the microwave region. A narrow field of view (22^o) altimeter is flown on the primary and secondary platforms, providing daily coverage of the earth to within 11^o of the poles.

RADAR ALT (22^o FOV)

MISS CAT / KNOWL REQ'T	DISASTER PRED. & ASSESSMENT	EARTH & OCEAN DYNAMICS	
Earthquake Prediction	Daily		
Wave Characteristics		Daily	

3.9 LASER ALTIMETER

A laser altimeter provides day and night ranging data in the visible-IR range. A narrow field of view (22^o) altimeter is flown on the primary and secondary platforms, providing twice-daily coverage of the earth to within 11^o of the poles.

MISS CAT / KNOWL REQ'T	LAND USE	DISASTER PRED. & ASSESSMENT	EARTH & OCEAN DYNAMICS
Land Topography	90 days		
Tidal Wave Prediction		Twice daily	
Earthquake Prediction		Daily	
Wave Characteristics			Daily
Tectonic Movement			30 days

3.10 MICROWAVE SCATTEROMETER

A microwave scatterometer provides all weather reflectance data in the high frequency (C band and up) microwave region. A narrow field of view (22^o)

scatterometer is flown on the primary and secondary platforms, providing daily coverage of the earth to within 11° of the poles.

MIC SCAT (22° FOV)

MISS CAT / KNOWL REQ'T	GEOLOGICAL RESOURCES	EARTH & OCEAN DYNAMICS	
Surface Texture	Occasionally		
Soil Density, Porosity	Occasionally		
Sea Surface Wind		Daily	

3.11 VIS-IR LIMB SOUNDER

A VIS-IR limb sounder provides vertical profiles of atmospheric properties by viewing the earth's limb while it is back-lighted by the sun. VIS-IR limb sounders are flown on the primary and supplemental platforms and are operated during the night portion of each orbit. The sounder on the primary platform observes the evening limb and the sounder on the supplemental platform observes the morning limb, providing nearly polar to polar coverage on a twice daily basis.

VIS-IR LIMB SOUNDER (TBD FOV)

MISS CAT / KNOWL REQ'T	ENVIRONMENTAL QUALITY	DISASTER PRED. & ASSESSMENT	
Tropospheric Gases/Aerosols	Daily		
Pollutant Transport	Daily		
Pollutant Distribution	Daily		
Storm/Flood Prediction		Twice daily	

3.12 VIS-IR VERTICAL SOUNDER

A VIS-IR vertical sounder provides vertical profiles of atmospheric properties while viewing downward along the nadir. A wide field of view (78°) sounder is flown on the primary and supplemental platforms, providing twice daily (morning and afternoon) coverage of the earth, including the poles.

VIS-IR VERT SOUNDER (78° FOV)

MISS CAT / KNOWL REQ'T	DISASTER PRED. & ASSESSMENT		
Storm/Flood Prediction	Twice daily		

3.13 MICROWAVE LIMB SOUNDER

A microwave limb sounder provides vertical profiles of atmospheric properties by viewing the earth's limb. Microwave limb sounders are flown on the primary and supplemental platforms and are operated during the night portion of each orbit to complement the data collected by the VIS-IR limb sounders. The sounder on the primary platform observes the evening limb and the sounder on the supplemental platform observes the morning limb, providing nearly polar to polar coverage on a twice daily basis.

MW LIMB SOUNDER (TBD FOV)

MISS CAT / KNOWL REQ'T	DISASTER PRED. & ASSESSMENT		
Storm/Flood Prediction	Twice daily		

3.14 MICROWAVE VERTICAL SOUNDER

A microwave vertical sounder provides vertical profiles of atmospheric properties while viewing downward along the nadir. A wide field of view (78°) sounder is flown on the primary and supplemental platforms, providing twice daily (morning and afternoon) coverage of the earth, including the poles, to complement the data collected by the VIS-IR vertical sounder.

MW VERT SOUNDER (78° FOV)

MISS CAT / KNOWL REQ'T	DISASTER PRED. & ASSESSMENT		
Storm/Flood Prediction	Twice daily		

3.15 LIDAR SOUNDER

A lidar sounder provides day and night vertical profiles of atmospheric properties while viewing downward along the nadir. A narrow field of view (22°) sounder is flown on the primary and secondary platforms, providing coverage of the earth to within 11° of the poles on a twice daily basis.

LIDAR SOUNDER (22° FOV)

MISS CAT / KNOWL REQ'T	DISASTER PRED. & ASSESSMENT	WEATHER & CLIMATE	ATMOSPHERE
Pressure Profile	Twice daily	Twice daily	Daily

3.16 IR SOUNDER

An IR sounder provides day and night vertical profiles of atmospheric properties in the far IR range. A wide field of view (78°) sounder is flown on the primary platform, providing twice daily coverage of the earth, including the poles.

IR SOUNDER (78° FOV)

MISS CAT / KNOWL REQ'T	DISASTER PRED. & ASSESSMENT	WEATHER & CLIMATE	ATMOSPHERE
Temperature Profile	Twice daily	Twice daily	Daily
Rate of Evaporation	Daily	Daily	

3.17 RADAR SOUNDER

A radar sounder provides vertical profiles of atmospheric properties while viewing downward along the nadir. A wide field of view (78°) sounder is flown on the primary and supplemental platforms, providing twice daily (morning

and afternoon) coverage of the earth, including the poles, to complement the data collected by the VIS-IR vertical sounder.

RADAR SOUNDER (78° FOV)

MISS CAT / KNOWL REQ'T	DISASTER PRED. & ASSESSMENT		
Storm/Flood Prediction	Twice daily		

3.18 IR DETECTOR

An IR detector provides day and night readings in the far IR range. A medium field of view (TBD) detector is flown on the primary platform, providing partial coverage of the earth to within TBD of the poles on a twice daily basis.

IR DET (TBD FOV)

MISS CAT / KNOWL REQ'T	ENVIRONMENTAL QUALITY	DISASTER PRED. & ASSESSMENT	WEATHER & CLIMATE
Wind Profile	Twice daily	Twice daily	Daily

3.19 IR POINTABLE DETECTOR

An IR pointable detector provides day and night readings in the far IR range while viewing a selected target. A medium field of view (TBD) detector is flown on the primary platform, providing coverage of selected targets anywhere on the earth, including the poles, on a daily basis.

IR POINT DET (TBD FOV)

MISS CAT / KNOWL REQ'T	DISASTER PRED. & ASSESSMENT	WEATHER & CLIMATE	
Solar Constant	Daily	Daily	

3.20 UV MAPPER

A UV mapper provides imagery in the UV range. Mission objectives and implementation are TBD.

3.21 LIDAR SPECTROMETER

A lidar spectrometer provides day and night multispectral imagery in the visible-IR range. Mission objectives and implementation are TBD.

3.22 LIDAR SCATTEROMETER

A lidar scatterometer provides day and night reflectance data in the visible-IR range. Mission objectives and implementation are TBD.

3.23 LASER SOUNDER

A laser sounder provides day and night vertical profiles of atmospheric properties while viewing on a line of sight between two platforms. Mission objectives and implementation are TBD.

3.24 UV LIMB SOUNDER

A UV limb sounder provides vertical profiles of atmospheric properties by viewing the earth's limb. Mission objectives and implementation are TBD.

3.25 MHz RADAR SOUNDER

A MHz radar sounder provides vertical profiles of atmospheric properties while viewing downward along the nadir. Mission objectives and implementation are TBD.

3.26 X-RAY DETECTOR

An X-ray detector provides readings of X-ray emissions from the earth's surface and limb. Mission objectives and implementation are TBD.

3.27 GAMMA RAY DETECTOR

A γ-ray detector provides readings of γ-ray emissions from the earth's surface and limb. Mission objectives and implementation are TBD.

3.28 EXTREME UV DETECTOR

An EUV detector provides readings of the far-UV emissions from the earth's surface and limb. Mission objectives and implementation are TBD.

3.29 DATA COLLECTION PLATFORM INTERROGATOR

A DCP interrogator accepts data dumps from DCPs that may be deployed throughout the land and ocean areas of the earth. An Adaptive Multi-beam Phased Array (AMPA) type of electrically pointed antenna would appear to be the most attractive implementation concept. Mission objectives are TBD.

3.30 FIELD/PARTICLE DETECTORS

Field and particle detectors include gravimeters, magnetometers, and sensors measuring extraterrestrial partial behavior in the near earth environment. Mission objectives and implementation are TBD.

MISSION SPECIFICATION

Geosynchronous Mission

1.0 INTRODUCTION

This document describes a generic geosynchronous mission that has been developed to satisfy a range of objectives in the earth resources and environmental discipline areas. The sensors that are assigned to this mission have been selected through an analysis of measurement requirements and have been examined for compatibility with the mission and with each other. The resulting mission combines timely coverage of abrupt events with long term synoptic surveillance.

The following sensors are assigned to this mission:

Geosynchronous Earth Observation System (GEOS)
Millimeter Wave Mapper
Geosynchronous Synthetic Aperture Radar (GEOSAR)

The following sensors may be included if mission requirements are established:

X-Ray Detector
γ-Ray Detector
EUV Detector

2.0 MISSION REQUIREMENTS

The following requirements pertain to the mission as a whole and define the characteristics of the mission and its implementing elements.

2.1 MISSION OBJECTIVES

The generic geosynchronous mission meets requirements for immediate coverage of abrupt events and long term surveillance of certain less dynamic phenomena. The mission is designed to benefit from the continuous target coverage and synoptic view provided by geosynchronous orbit. The mission is assigned a near-geostationary orbit to minimize seasonal lighting effect on target coverage, with a small relative motion provided to satisfy GEOSAR requirements.

2.2 MISSION PARAMETERS

The mission uses a geosynchronous orbit with an inclination of 1°, an eccentricity of 0.009, and an argument of perigee of 90°. This produces a near-circular subsatellite track centered about fixed point on the earth's equator. Viewing of earth targets that lie within about 60° of latitude and longitude of the fixed point is possible on a 24 hour basis, subject to lighting constraints and GEOSAR incidence angle requirements.

Four platforms provide complete coverage of the earth between 60° north and south latitude. (Coverage above 60° may be possible for some applications.) The platforms are positioned to allow GEOSAR viewing of major land areas. Their locations are:

105° W for North America, South America
165° E for Australia, East Asia
75° E for East Africa, West/South/Central Asia
15° W for Europe, West Africa

2.3 OPERATIONS

The GEOS generally operates during the daylight portion of each orbit. The MW mapper and GEOSAR operate day or night as required. GEOS and the MW mapper are pointed in a mapping mode or at specific targets of interest. GEOSAR is operated in a mapping mode.

2.4 INSTALLATION

Platforms and sensors will be installed in orbit in accordance with STS capabilities and practices existing in the 1990s. These may include LEO or GEO assembly, modular buildup, and orbit transfer activities. Provision should be made for sensor additions, modifications, or replacements, performed either on orbit or by means of retrieval and reflight.

2.5 MAINTENANCE

Platforms and sensors will be maintained during their operating lifetime in accordance with STS capabilities and practices existing in the 1990s. Maintenance will be accomplished either on orbit or by means of retrieval and reflight.

3.0 SENSOR REQUIREMENTS

The following requirements pertain to the individual sensors included in the mission. Sensor descriptions and operating parameters are traced to mission objectives and measurement requirements.

3.1 GEOSYNCHRONOUS EARTH OBSERVATION SYSTEM

GEOS is a large optical system in whose image plane is a two dimensional array of Change Injection Devices (CIDs). The CIDs allow selected readouts and continuous geometric image correction. Coarse, medium, or fine resolution imagery is provided by differentiated array geometry and variable readout patterns. Coarse resolution imagery is obtained over a total field of view of 1°, while fine resolution imagery is restricted to a 0.01° spot in the center of the total field. Ground coverage is approximately 350 nmi (560 km) square for the wide field and 3.5 nmi (5.6 km) square for the high resolution spot. The system is pointable to cover the entire visible portion of the earth.

GEOS (1^{o} FOV)

KNOWL REQ'T \ MISS CAT	AGRICULTURE	RANGE MGT	FORESTRY
Vegetation Identification	90 days	90 days	Yearly
Vegetation Distribution	90 days	90 days	Yearly
Plant Development	15 days	15 days	Yearly
Plant Vigor	15 days	15 days	Yearly
Plant Growth	15 days	15 days	90 days
Plant Stress	15 days	15 days	90 days
Soil Moisture			30 days
Grazing Intensity		60 days	
Soil Surface Comp	Occasionally	Occasionally	Occasionally
Land Topography	Occasionally	Occasionally	

KNOWL REQ'T \ MISS CAT	GEOLOGICAL RESOURCES	LAND USE	WATER RESOURCES & OCEAN
Vegetation Identification	Occasionally		
Subsoil Composition	Occasionally		
Buildings/Structures		90 days	
Roads/Railroads		90 days	
Water Body Chemicals			5 days
Plankton Distribution			5 days
Fish Location & Dist.			Daily
Fishing Patterns			Daily
Red Tides			Daily

KNOWL REQ'T \ MISS CAT	ENVIRONMENTAL QUALITY	DISASTER PRED. & ASSESSMENT	EARTH & OCEAN DYNAMICS
Ocean Pollution	Daily		
Oil Spill Surveillance	Daily		
River/Lake Pollution	Daily		
Storm/Flood Prediction		Twice daily	
Structure/Flora Damage		Daily	
Ocean Currents			15 days
Estuary Circulation			90 days
Shoreline Shifts			Yearly

3.2 MILLIMETER WAVE MAPPER

A millimeter wave mapper provides all weather imagery in the high frequency (Q, U W band) microwave region. Coarse resolution imagery is obtained over a total field of view of 5^{o}, which gives ground coverage of approximately 2000 nmi

(3200 km) square. The mapper is pointable to cover the entire visible portion of the earth.

MMW MAP (5^{o} FOV)

MISS CAT / KNOWL REQ'T	AGRICULTURE	RANGE MGT	FORESTRY
Soil Composition	Occasionally	Occasionally	Occasionally

MISS CAT / KNOWL REQ'T	DISASTER PRED. & ASSESSMENT		
Storm/Flood Prediction	Twice daily		

3.3 GEOSYNCHRONOUS SYNTHETIC APERTURE RADAR

The GEOSAR provides all weather imagery in the S-band microwave range. Medium resolution imagery is obtained by utilizing satellite motion relative to geostationary position. An orbit with an inclination of 1^{o}, an eccentricity of 0.009, and an argument of perigee of 90^{o} produces a near circular sub-satellite track. A total field of view of 1^{o} gives an approximately 350 nmi (560 km) footprint on the earth. The antenna is side looking and is adjustable in elevation. Target tracking is required for integration times of up to 700 sec per beam footprint.

GEOSAR (1^{o} FOV)

MISS CAT / KNOWL REQ'T	AGRICULTURE	RANGE MGT	FORESTRY
Plant Density	15 days	15 days	Yearly
Soil Moisture		15 days	
Standing Timber			Yearly

MISS CAT / KNOWL REQ'T	GEOLOGICAL RESOURCES	LAND USE	WATER RESOURCES & OCEAN
Standing Timber		Yearly	
Geo. Deposits/Formations	Occasionally		
Ice Formations			5 days
Ocean Pollution			5 days

MISS CAT / KNOWL REQ'T	DISASTER PRED. & ASSESSMENT	EARTH & OCEAN DYNAMICS	
Ice Formations	Daily		
Earth Crustal Faults		30 days	

3.4 X-RAY DETECTOR

An X-ray detector provides readings of X-ray emissions from the earth's surface and limb. Mission objectives and implementation are TBD.

3.5 GAMMA RAY DETECTOR

A γ-ray detector provides readings of γ-ray emissions from the earth's surface and limb. Mission objectives and implementation are TBD.

3.6 EXTREME UV DETECTOR

An EUV detector provides readings of the far-UV emissions from the earth's surface and limb. Mission objectives and implementation are TBD.

MISSION SPECIFICATION

Non Sun Synchronous, Non Geosynchronous Mission

1.0 INTRODUCTION

This document describes a generic non sun synchronous, non geosynchronous mission that has been developed to satisfy a broad range of objectives in the earth resources and environmental discipline areas. The sensors that have been assigned to this mission have been selected through an analysis of measurement requirements and have been examined for compatibility with the mission and with each other. The resulting mission emphasizes all weather coverage of non-dynamic phenomena.

The following sensors are assigned to this mission:

Microwave Mapper	Synthetic Aperture Radar
Low Frequency Mapper	Spectral Mapper
Lidar Mapper	Stereo Mapper
Radar Mapper	Pointable Mapper
	Laser Altimeter

The following sensors may be included if mission requirements are established:

UV Mapper	UV Limb Sounder	DCP Interrogator
Lidar Spectrometer	MHz Radar Sounder	EUV Detector
Laser Scatterometer	X-Ray Detector	Field/Plasma Sensors
Laser Sounder	γ-Ray Detector	

2.0 MISSION REQUIREMENTS

The following requirements pertain to the mission as a whole and define the characteristics of the mission and its implementing elements.

2.1 MISSION OBJECTIVES

The generic non sun synchronous, non geosynchronous mission meets requirements for high resolution coverage of non dynamic phenomena. The mission is designed to provide complete coverage of the temperate and tropical zones of the earth

on a 15 day repeat cycle. The mission has been assigned a relatively high altitude to minimize orbit decay for a large platform with a low ballistic coefficient. Emphasis is on microwave and active sensors that are insensitive to the day/night cycle.

2.2 MISSION PARAMETERS

The mission uses an orbit at an altitude of 880 nmi (1630 km) and an inclination of 60°. This orbit provides a 15 day repeat cycle with 181 revolutions. Complete coverage of the tropics and the temperate zones to 61° north and south is obtained every 15 days by sensors whose total field of view is 10°.

A single platform carries a full complement of sensors for narrow field (10°) coverage of the temperate and tropical zones on a 15-day cycle. Orbital precession ($\sim 6^{\circ}$/day) causes constantly changing lighting conditions for which no apparent optimum variation exists; hence launch time and first nodal crossing are unconstrained.

2.3 OPERATIONS

Nicrowave and active sensors operate day or night as required. The passive optical sensors operate only during the daylight portion of the orbit. The pointable mapper observes descrete targets which it acquires and tracks when lighting conditions are right.

2.4 INSTALLATION

Platform and sensors will be installed in orbit in accordance with STS practices and capabilities existing in the 1990s. These may include direct injection, modular buildup, and orbit transfer activities. Provision should be made for sensor additions, modifications, or replacements, performed either on orbit or by means of retrieval and reflight.

2.5 MAINTENANCE

Platform and sensors will be maintained during their operating lifetime in accordance with STS capabilities and practices existing in the 1990s. Maintenance will be accomplished wither on orbit or by means of retrieval and reflight.

3.0 SENSOR REQUIREMENTS

The following requirements pertain to the individual sensors included in the mission. Sensor descriptions and operating parameters are traced to mission objectives and measurement requirements.

3.1 MICROWAVE MAPPER

An MW mapper provides all weather imagery in the microwave range. Surface resolution and penetration are dependent on operating frequency and antenna size. One or more antennas are operated at several frequencies and view along the nadir.

MW MAP (10^{o} FOV)

MISS CAT / KNOWL REQ'T	AGRICULTURE	RANGE MGT	FORESTRY
Soil Moisture	15 days		
Soil Composition	Occasionally	Occasionally	Occasionally

3.2 LOW FREQUENCY MAPPER

A low frequency mapper provides all weather imagery in the metric/decimetric microwave range (I, G, P, L, S band). One antenna views along the nadir.

LOW F MAP (10^{o} FOV)

MISS CAT / KNOWL REQ'T	AGRICULTURE		
Method of Cultivation	Yearly		

3.3 LIDAR MAPPER

A lidar mapper provides day and night monochromatic imaging in the visible-IR range. The mapper views along the nadir.

LIDAR MAP (10^{o} FOV)

KNOWL REQ'T \ MISS CAT	AGRICULTURE	RANGE MGT	LAND USE
Building/Structures			90 days
Roads/Railroads			90 days
Land Topography	Occasionally	Occasionally	

KNOWL REQ'T \ MISS CAT	EARTH & OCEAN DYNAMICS		
Shoreline Shifts	Yearly		

3.4 RADAR MAPPER

A radar mapper provides all weather imagery in the microwave range. A fore or aft-looking antenna is flown.

KNOWL REQ'T \ MISS CAT	AGRICULTURE	RANGE MGT	FORESTRY
Plant Density	15 days	15 days	Yearly
Soil Moisture		15 days	
Standing Timber			Yearly

KNOWL REQ'T \ MISS CAT	LAND USE		
Standing Timber	Yearly		

3.5 SYNTHETIC APERTURE RADAR

A SAR provides all weather imagery in the microwave range. A side-looking (northward) antenna is flown.

SAR (10° FOV)

KNOWL REQ'T \ MISS CAT	FORESTRY	LAND USE	
Standing Timber	Yearly	Yearly	

3.6 SPECTRAL MAPPER

A spectral mapper provides multispectral imagery in the visible-IR range. The mapper views along the nadir.

SPECT MAP (10° FOV)

KNOWL REQ'T \ MISS CAT	AGRICULTURE	RANGE MGT	FORESTRY
Vegetation Identification	90 days	90 days	Yearly
Vegetation Distribution	90 days	90 days	Yearly
Plant Stress	15 days	15 days	90 days
Soil Moisture			30 days
Soil Surface Comp	Occasionally	Occasionally	Occasionally

3.7 STEREO MAPPER

A stereo mapper provides monochromatic or polychromatic overlapping imagery in the visible-IR range. The mapper views along the nadir.

STEREO MAP (10° FOV)

KNOWL REQ'T \ MISS CAT	AGRICULTURE	RANGE MGT	LAND USE
Buildings/Structures			90 days
Roads/Railroads			90 days
Land Topography	Occasionally	Occasionally	

MISS CAT / KNOWL REQ'T	EARTH & OCEAN DYNAMICS		
Shoreline Shifts	Yearly		

3.8 POINTABLE MAPPER

A pointable mapper provides imagery in the visible-IR range while viewing a selected target.

POINT MAP (TBD FOV)

MISS CAT / KNOWL REQ'T	AGRICULTURE	RANGE MGT	FORESTRY
Plant Development	15 days	15 days	Yearly
Plant Vigor	15 days	15 days	Yearly
Plant Growth	15 days	15 days	90 days
Grazing Intensity		60 days	

3.9 LASER ALTIMETER

A laser altimeter provides day and night ranging data in the visible-IR range. The altimeter views along the nadir.

MISS CAT / KNOWL REQ'T	LAND USE		
Land Topography	90 days		

3.10 UV MAPPER

A UV mapper provides imagery in the UV range. Mission objectives and implementation are TBD.

3.11 LIDAR SPECTROMETER

A lidar spectrometer provides day and night multispectral imagery in the visible IR range. Mission objectives and implementation are TBD.

3.12 LIDAR SCATTEROMETER

A lidar scatterometer provides day and night reflectance data in the visible-IR range. Mission objectives and implementation are TBD.

3.13 LASER SOUNDER

A laser sounder provides day and night vertical profiles of atmospheric properties while viewing on a line of sight between two platforms. Mission objectives and implementation are TBD.

3.14 UV LIMB SOUNDER

A UV limb sounder provides vertical profiles of atmospheric properties by viewing the earth's limb. Mission objectives and implementation are TBD.

3.15 MHz RADAR SOUNDER

A MHz radar sounder provides vertical profiles of atmospheric properties while viewing downward along the nadir. Mission objectives and implementation are TBD.

3.16 X-RAY DETECTOR

An X-ray detector provides readings of X-ray emissions from the earth's surface and limb. Mission objectives and implementation are TBD.

3.17 GAMMA RAY DETECTOR

A γ-ray detector provides readings of γ-ray emissions from the earth's surface and limb. Mission objectives and implementation are TBD.

3.18 EXTREME UV DETECTOR

An EUV detector provides readings of the far-UV emissions from the earth's surface and limb. Mission objectives and implementation are TBD.

3.19 DATA COLLECTION PLATFORM INTERROGATOR

A DCP interrogator accepts data dumps from DCPs that may be deployed throughout the land and ocean areas of the earth. An Adaptive Multi-beam Phased Array (AMPA) type of electrically pointed antenna would appear to be the most attractive implementation concept. Mission objectives are TBD.

3.20 FIELD/PARTICLE DETECTORS

Field and particle detectors include gravimeters, magnetometers, and sensors measuring extraterrestrial partial behavior in the near earth environment. Mission objectives and implementation are TBD.

APPENDIX C

IMPLEMENTATION PLAN

1.0 GENERAL

This plan outlines and describes the tasks to be performed during the contract period for the generation of three generic mission class specifications. The specifications for the three classes (sun-synchronous, non-sun-synchronous and geosynchronous) will be documented as separate specifications and submitted as the final report to this contract.

Section 2 of this plan contains the detailed contract task descriptions and describes the activities incorporated in each task, identifying their required inputs and resultant outputs. Each task is constructed to generate data required for the logical development of the mission specifications and allows iterative assessment, when required, to optimize the task results.

Section 3 contains the contract task and milestone schedule depicting significant milestone dates and contract reporting events.

2.0 TASK DESCRIPTIONS

The contract tasks described in this section are derived from, and are parallel to, our approach described in the Study Proposal. Each task contributes to the development of the mission specifications by developing the necessary inputs to specify (1) mission categories, (2) mission objectives), (3) measured parameters, (4) sensor descriptions, and (5) mission parameters.

2.1 TASK 1 MISSION OBJECTIVE

A thorough review of our in-house mission data base consisting of TERSSE, Outlook for Space, EVAL, PLACE, Nimbus, etc., coupled with the JPL GSS

study will be the mechanism for determining the initial set of applicable mission objectives. These objectives will then be grouped into their related earth resources and environmental categories and presented at the contract kick-off meeting for customer review and approval. Subsequent to their approval, the categorized objectives will be assessed to identify their measurement requirements and their applicability to space or non-space sensing. Those objectives/categories applicable to space related sensing will form the baseline for the study and provide the inputs for the mission categories and mission objectives in the three mission specifications.

2.2 TASK 2 CANDIDATE SENSORS

Sensor candidates for this task will be limited to those already identified and characterized in at least a preliminary manner in studies such as TERSSE, PLACE, GSS circa 1995, etc. Exceptions may be made if the mission objective task results in definition of mission parameters which are considered vital, but for which no suitable sensor candidate definition exists. Further, the candidate sensors identified as a result of this task will be limited to those that are rated at least "semi-credible" on the PLACE credibility scale.

With the mission objectives and their measurement parameters known from Task 1, the data base of "known" sensors will be surveyed and one or more candidates for each measurement will be identified and assigned a suitability value based upon the desirable characteristics for use in a future space platform system. This suitability value will be derived from consideration of the contribution to these selection criteria:

- Ability to make the required measurement with the required accuracy
- Ability of the sensor to contribute to multiple mission objectives
- Be typical of expected future challenges (e.g., vibration and control jitter, cryogenic temperatures, etc.)
- Incorporate a technology state of the art not expected to be obsolete ten years from now.
- Possibility of synergistic results when combined with other sensor candidates.

2.3 TASK 3 OPERATING REQUIREMENTS

Sensor operating requirements determine the orbits in which the sensor can operate, and define the operation of the sensor in orbit. Requirement parameters that are important to this study will be identified by examining sensor performance data developed in Task 2, and anticipating compatibility criteria to be used in subsequent tasks. Each candidate sensor will be considered in turn and its operating requirements will be determined. The operating requirements will define acceptable ranges of orbit parameters and will describe on orbit sensor operations in sufficient detail to permit identification of operational incompatibilities. The individual sensor requirements data will be collected in a matrix to provide visibility for the compatibility analyses. The matrix will list operating requirements for each sensor, including alternate implementations and variable requirements sets.

2.4 TASK 4 MISSION COMPATIBILITY

This task will establish the compatibility of candidate sensors with various orbits in each of the three mission classes. Criteria for first

order compatibility will be established, including allowable altitudes and inclinations, targets to be viewed, and repeat cycle requirements. Additional considerations such as sun angle limits, time of year, obliquity allowed/required, and success probability per attempt will be included.

Operating requirements ranges established in Task 3 will be compared to determine sensor compatibility with various potential orbits. These orbits will be selected to satisfy specific requirements for target coverage, repeat cycles, and measurement quality for certain individual sensors; they will cover the range of orbits within each of the three mission classes. The suitability of these orbits for other sensors will be examined and rated as "acceptable," "marginal," or "unacceptable." "Acceptable" will signify that the sensor in question could function in that particular orbit with no significant degradation of its performance and measurement capability. "Marginal" will mean that the sensor would operate at less than its full capability if that particular orbit were used, but that useful measurement information could be obtained. "Unacceptable" will rule out the potential orbit as far as that sensor is concerned.

The result of this effort will be definitions of sensor groups that could be flown in specific orbits in each of the three mission classes. Using stringently constrained sensors or other core-emphasis sensors as starting points, mission compatible sensor groups will be identified. The resulting sensor groups will be subjectively evaluated, and those deemed most suitable for study purposes will be carried forward to Task 5.

2.5 TASK 5 SENSOR COMPLEMENTS

This task will evaluate the mission compatible sensor groups identified in Task 4 for operations compatibility. Criteria for second order compatibility will be established based on key operations requirements identified for the candidate sensors. Ranges of requirements for the sensors within each mission compatible group will be compared. The core or emphasis sensor in each group will be baselined, and the operation of the other sensors will be judged "acceptable," "marginal," or "unacceptable" in relation to the baseline. "Marginal" and "unacceptable" operations can result from impact of baseline on sensor, sensor on baseline, or both.

Sensors found "acceptable" will be retained in the mission compatible group. "Marginal" sensors will be retained only if their mission compatibility is not also "marginal." The resulting compatible groups will be given a final check for non-baseline sensor-to-sensor compatibility and will be carried forward into Task 6.

2.6 TASK 6 MISSION DEFINITIONS

Missions will be defined through a logical approach of establishing mission assessment criteria for the envisioned sensing platform's physical and operational capabilities, defining an emphasis flight objective and testing sensor groupings to these criteria.

Each sensor group will have an emphasis sensor/objective as the key element to that mission. Additional sensors will be combined to the emphasis sensor to augment that mission objective while complying with mission constraints. Should a sensor complement exceed the parameters of the platform constraints,

the group will be modified and/or reassigned to additional platforms. Requirements for fleet size will be determined from the measurement requirements and sensor concepts identified to meet the mission objectives.

The results of this assessment will be a general grouping of platform sensors organized by orbital configuration and complying with its platform constraints and the logistics of the STS. From these groupings, mission specifications for the three classes of orbits will be generated, identifying their particular mission categories, mission objectives, measured parameters, sensor descriptions and mission parameters.

3.0 IMPLEMENTATION SCHEDULING

The performance of the Mission Specification Study will be in accordance with the schedule shown in Figure 3-1. This schedule is in compliance with the requirements of the RFP. The major part of the study effort will be accomplished in the first two months of the study.

The study commences with identification of mission objectives for earth resources and environmental disciplines, extending the PLACE study baseline to additional mission categories. Candidate sensors are then identified, their operating requirements are defined, and mission compatibility is assessed. Sensor complements for three generic mission classes are defined, using selection criteria developed from mission objectives and sensor compatibilities. The resulting missions are defined in sufficient detail to establish orbit parameters, sensor characteristics, and operational requirements. The output of the study is a final report containing summary presentation material and mission specifications that relate and define mission categories, mission objectives, measured parameters, sensor complements, and mission parameters for the three generic mission classes.

In addition to the required oral review two months after contract start, informal reviews are scheduled during the first and fourth weeks of the contract. The first week's review is a kick-off meeting at which the Implementation Plan will be finalized and initial study direction will be defined. The fourth week's review is a mid-term meeting at which mission objectives, candidate sensors, and operating requirements will be discussed, along with direction for the second month of the study.

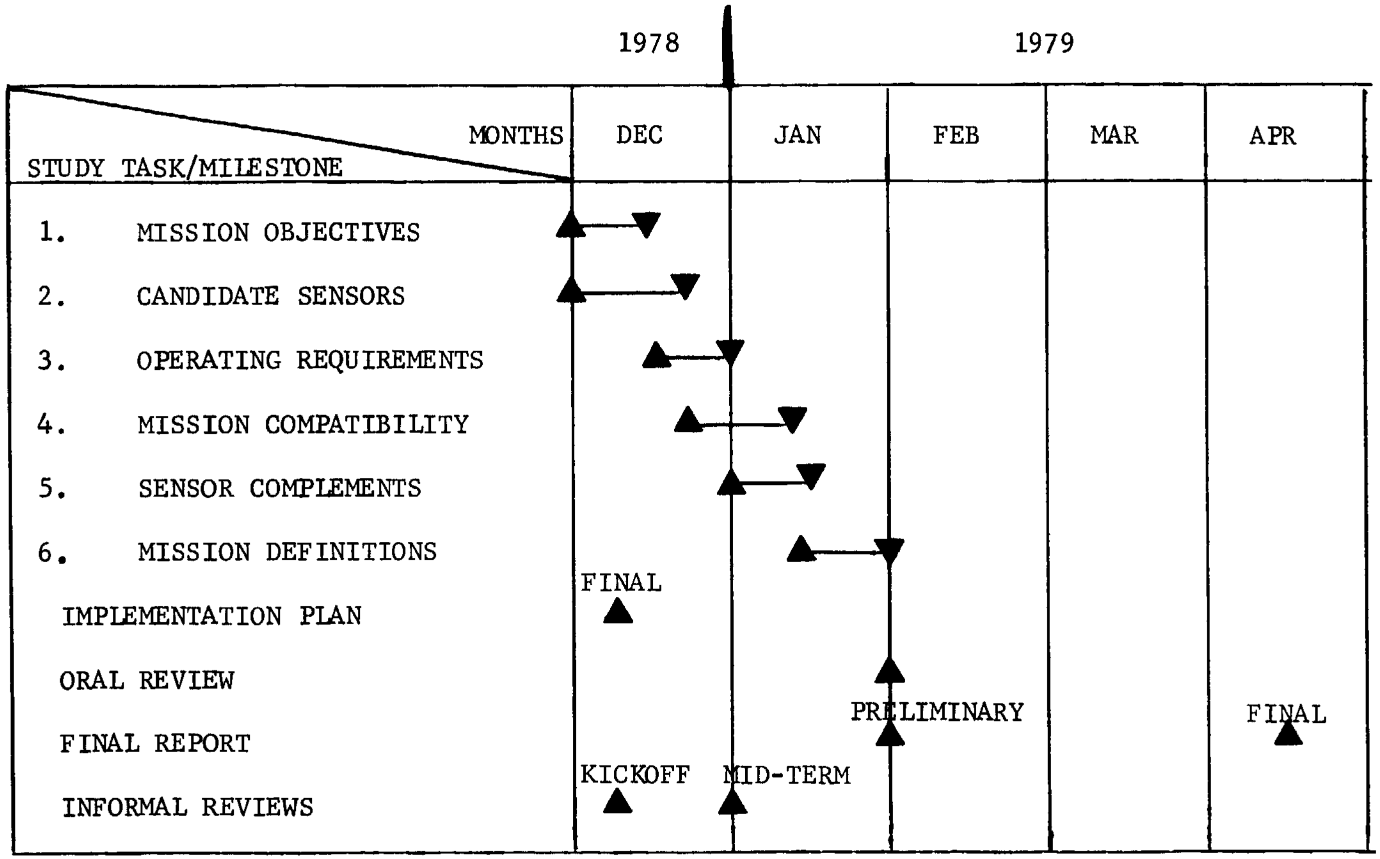

Figure 3-1. Task and Milestone Schedule